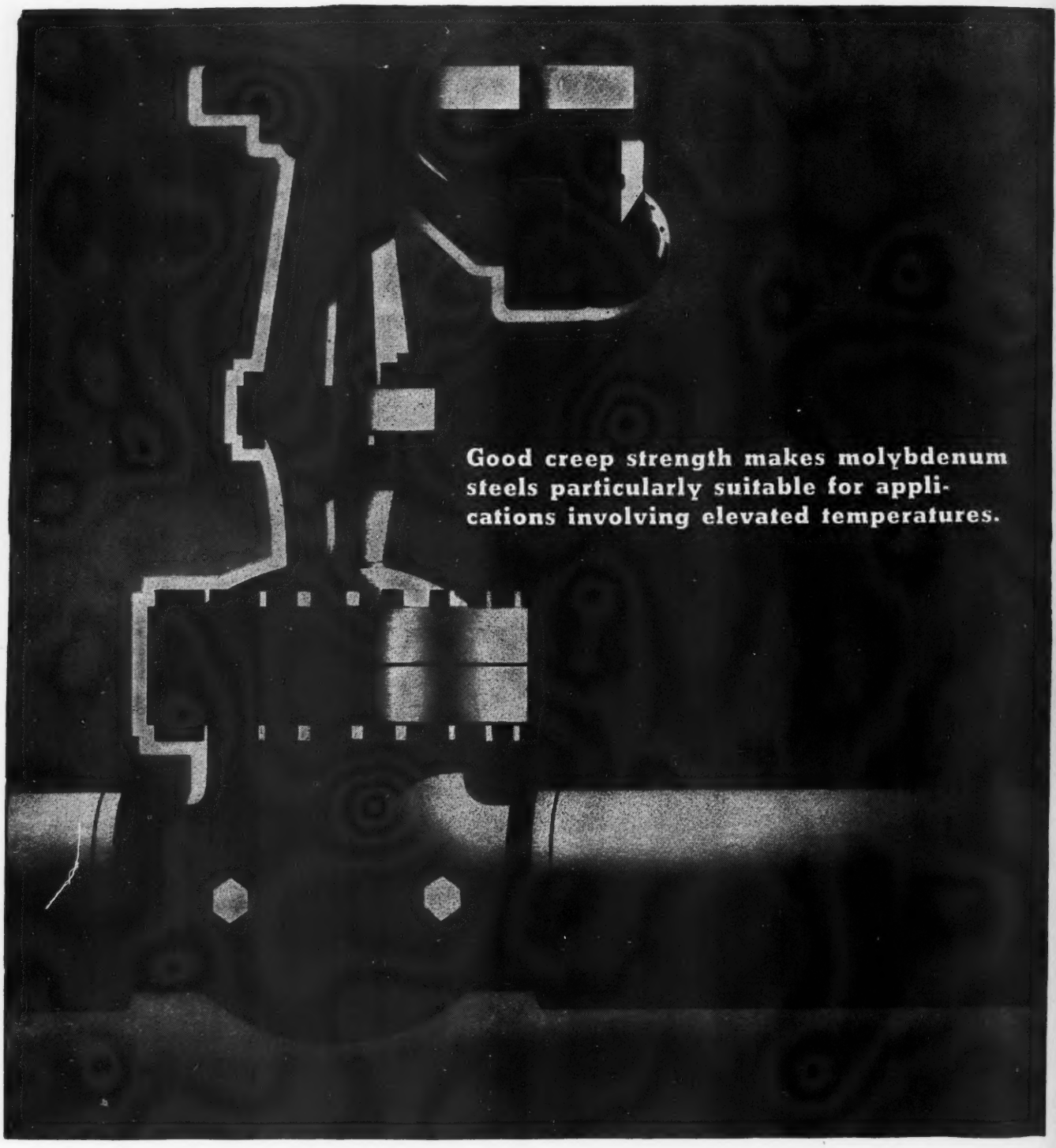
APRIL 1946

The Tech Engineering News

TWENTY-FIVE CENTS
VOLUME XXVII, NO. 8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The first paper mill in America was built in 1690 by William Rittenhouse, a Mennonite preacher, from Amsterdam. The mill was situated on a little creek in what is now Fairmount Park in Philadelphia.

Linen rags — the product of flax which was raised in the vicinity — supplied the raw material, and the paper was said to be of excellent quality. Rittenhouse employed four men to do the work. The man in the picture is shaking pulp in a hand mold, forming the rough sheet of paper.

Today there are nearly a thousand mills in the country, producing annually more than 17 million tons of pulp and paper. The bearings they use . . . in their grinders, their cylinder molds, their press rolls, their driers . . . are in many cases supplied by SKF who pioneered in the paper industry. Mill executives and production engineers have come to rely more and more on SKF Anti-friction Bearings to improve efficiency and reduce operating costs.

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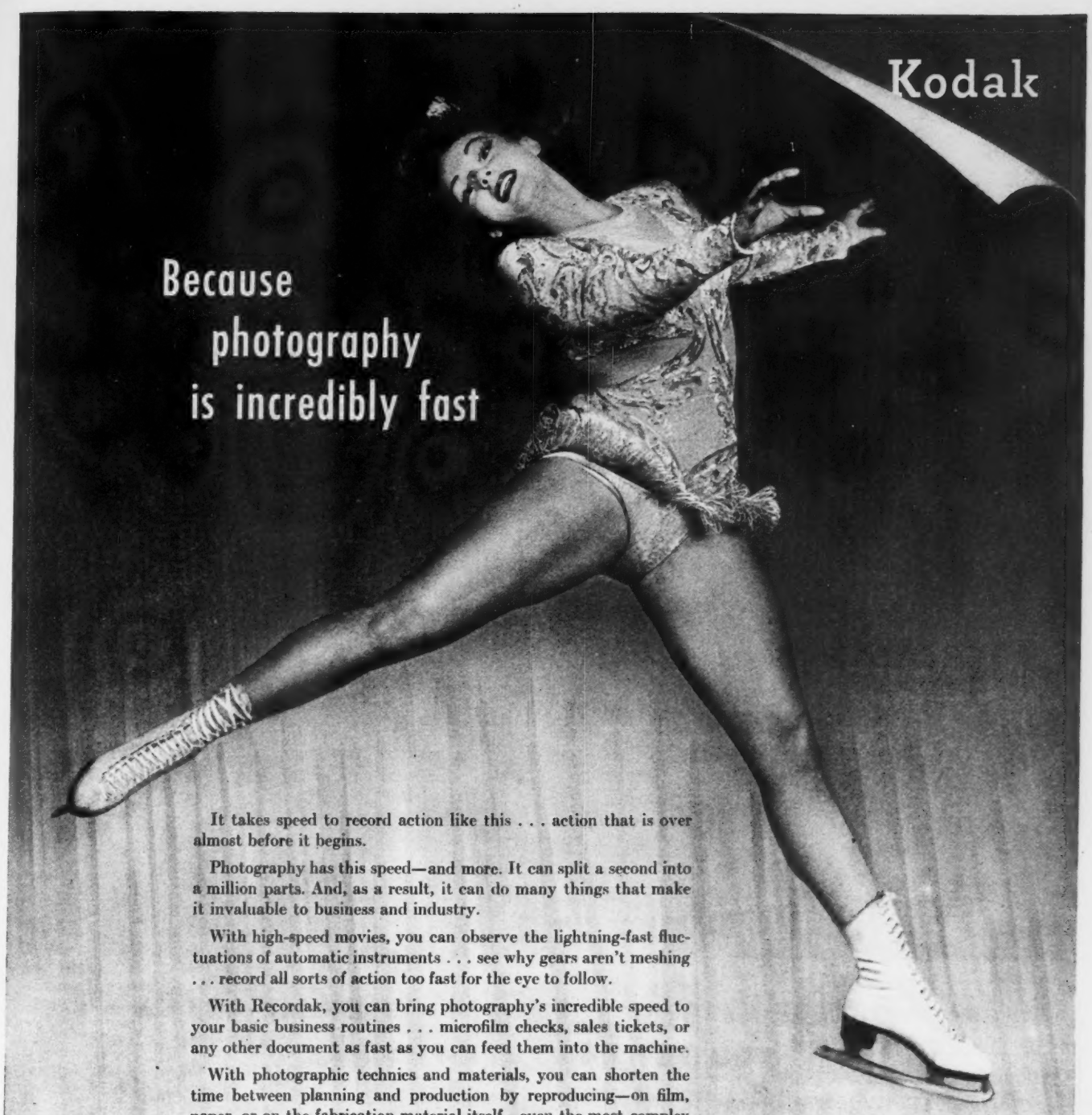

It takes speed to record action like this . . . action that is over almost before it begins.

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Stop here . . . and you only scratch the surface of what modern functional photography can do for plant and office operations. But go one step further... send for our new booklet, "Functional Photography"... and you'll really begin to get some idea of its present-day usefulness. This booklet is free. Write for it.

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ADVANCING BUSINESS AND INDUSTRIAL TECHNICS — **Functional Photography**

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HEADQUARTERS FOR MECHANICAL COOLING SINCE 1885

Du Pont *Digest*

Items of Interest in the Fields of Chemistry, Engineering, Physics, and Biology

NYLON—PRODUCT OF PURE RESEARCH

NYLON exists today because of curiosity—the curiosity of a group of Du Pont chemists who wanted to know more about polymerization, that strange process by which small molecules of a chemical unite to form larger molecules with entirely new and different chemical properties.

Du Pont chemists began a study of polymerization in 1928. They experimented with dibasic acids and within two years had succeeded in forming polyesters with molecular weights up to 25,000. In the spring of 1930, on removing one of these "superpolymers" from the molecular still, one of the chemists noted that it could be drawn out into a thin strand, like taffy candy. But, unlike taffy, it was not brittle when cooled. In fact, the cooled strand could be further drawn out to several times its former length and when so drawn became not only stronger but elastic!

This original ester polymer had a low melting point and was sensitive to water. Nevertheless, it suggested that some related type of polymer might produce fibers which would be of practical use in textiles.

Numerous superpolymers were synthesized and tested. Finally, in 1935, a polyamide was prepared. From it, the first nylon filaments were made—by forcing the molten polymer through a hypodermic needle!

Nylon Polymer Developed

Further experimental work resulted in the development of a polymer that possessed the desired characteristics. This material was later christened nylon.

But the job was not yet done. Research chemists—particularly physical chemists—and chemical engineers were called upon to devise practical methods for making the polymer and for spinning and drawing it into high-quality yarn. Mechanical engineers were given the task of designing plant equipment to carry out the processes. Organic chemists were required to develop new dyeing agents and to find a size to make knitting possible. At one time or another more than 230 research men, engineers and marketing specialists worked on the giant task of converting this child of chemical curiosity into a marketable product.

RESEARCH LOWERS PRICE OF SYNTHETIC UREA

Lower prices, as well as new processes, can result from intensive research. Take synthetic urea, for example. In 1930, urea sold for about 80¢ a pound. Great promise was held for this compound as an industrial chemical for fertilizer and plastic use—if an inexpensive manufacturing process could be found.

By methods then in use, ammonia and carbon dioxide were heated to about 150°C., forming urea and water in equilibrium with the unconverted original compounds. The yield of urea was approximately 43%.

Research by Du Pont chemists and engineers showed that, by adjusting the proportions of the reactants, raising the temperature and increasing the pressure, conversion could be improved materially. But the corrosive mixture resulting quickly chewed up the best grades of steel available.

Long investigation by metallurgists, chemists and chemical engineers finally produced an autoclave in which the operation could be carried on a production basis. Today, Du Pont is able to sell synthetic urea for less than 4¢ a pound. Men of Du Pont take pride in the fact that their work has made it possible to reduce the price of urea from the "drug" class to a level where it can be used as a fertilizer by the farmer.

Questions College Men ask about working with Du Pont

"WHAT ADVANTAGES DOES DU PONT OFFER A RESEARCH MAN?"

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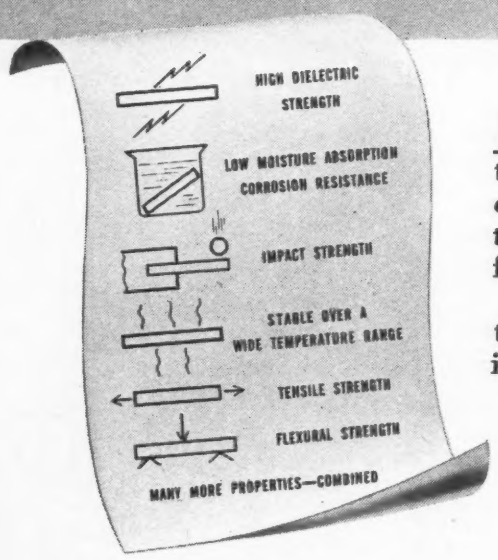

As ANY coal miner will tell you, this is a fused "trolley tap", a quick and easy means of siphoning power for electric cutters, drills and loaders from mine trolley wires.

The case is made from Synthane laminated phenolic tubing for mechanical strength and dielectric properties, and lined with asbestos for resisting the flash of the fuse it contains. Use plastics not for some vague magic in the name "plastics" but for their real advantages. And by all means, use plastics where they rightfully belong.

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The TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Published monthly during the school year at Walker Memorial, Cambridge 39, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology. Entered as second class matter, at the Post Office, June 1, 1920, at Boston, Mass. under the Act of March 3, 1879. Copyright 1946 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. One copy 25 cents.

This member of a club provided with laissez-faire leadership shows the general reaction of unhappiness and psychological frustration.

The Research Center for Group Dynamics

By EDWARD T. MILLER, '49

Pictures courtesy of the Research Center

THE Research Center for Group Dynamics at M. I. T. was established in February, 1945, as part of the Graduate School of the Department of Economics to carry out experimental studies of the factors which influence the attitudes, action, and gen-

Dr. Kurt Lewin, director of the Research Center at M.I.T.

eral atmosphere of groups of human beings. Dr. Kurt Lewin, noted psychologist, widely accredited for his work in psychological theory and experimentation, was instrumental in the creation of the Center and has been its director since its inception. While there are a few places carrying on research in specific fields which could be considered to border on group dynamics, the Center at M. I. T. is something entirely new and definitely unique.

Research in group dynamics involves experimentally investigating the forces acting on and within a group of people, which make that group function as it does. The group is seen and studied as a dynamic rather than as a static entity. In true experimental manner the research attempts to hold constant all but certain chosen factors in a given situation, to vary the selected factors in a specific way, and to record the results of the variations. For instance, the Center might study the leadership factor in respect to variations in group functioning, such as group cohesion and unity, or group production, by submitting experimental groups to certain types of leadership and recording the difference each type made on subsequent group behavior. It might experiment in a natural setting with how the various ways a foreman handles a particular group in a factory affect the group's productivity.

Such research finds its basis to a great extent in group psychology. This is not to be confused with mob psychology, for here the point of study is usually the face-to-face group. Group dynamics is not, however, just a fancy term for dealing with group psychology; it is much broader than that. While dependent on individual as well as group psychology for certain tools to work with, group dynamics, as Dr. Lewin envisions it, covers the whole of group life from its economics to the common and individual history of its members. Group dynamics welds sociology, psychology, and cultural anthropology into one science. Sociology, economics, and also cultural anthropology, when it is taken to include the present-day and specific cultures of particular groups of human beings, such as that of business women or inhabitants of a small town in, say, the South, all call for experimental studies of groups to give verification and firmer basis to their theories.

That is the main effort of the Research Center — to turn the whole field of group knowledge into a science according to the same standards by which physics or chemistry is considered a science. This involves studying every aspect of the group and every force that influ-

This club member working in a democratic group atmosphere is deeply engrossed in his work

ences the group, for only then can any facts derived be workable and have significance.

To fit these requirements, such a study might appear to be so complex that it would be impossible to make any headway towards discovering the facts behind group action. It should, however, be borne in mind that any experiment would deal with only a few

This laissez-faire club shows little unity but in its stead a great deal of horse-play. The two boys in the rear are carving on the posts in disobedience and disregard for the leader.

variables, as in physics, and that the problem would be to keep all other factors constant.

One of the fundamental assumptions on which group dynamics bases its approach is the belief that it is not necessarily more difficult experimentally to affect attitudes and behavior of individuals in groups than with individuals alone. It is like studying the molecule or the ion in the physical and chemical sciences. Sometimes it is easier to study one than the other, depending to a great extent on what the goal is or for what the research is being made. Similarly both approaches are important, because they either supplement each other or at times cover entirely different fields.

Since the research program is so broad, the Center has need of others besides psychologists. Close coöperation exists between the Center and the other branches of the Economics Department, especially the very active Industrial Relations Section. A statistician and a mathematician are working with the Center. It is not hard to understand the need for a statistician when you realize that often the major problem is to give meaning to all the data collected. Far more is involved in being accurate than just taking averages at random from the mass of data. But the mathematician perhaps seems out of place; that is, until the fact that the Center is trying to develop a new science is seen.

Since knowledge cannot truly be classified as science until its facts can accurately be measured and represented by figures, the Center must formalize its work. Present mathematics, unfortunately, is not always a suitable vehicle for doing this, so the mathematician is attempting to develop new mathematical relationships which will serve group dynamics more effectively.

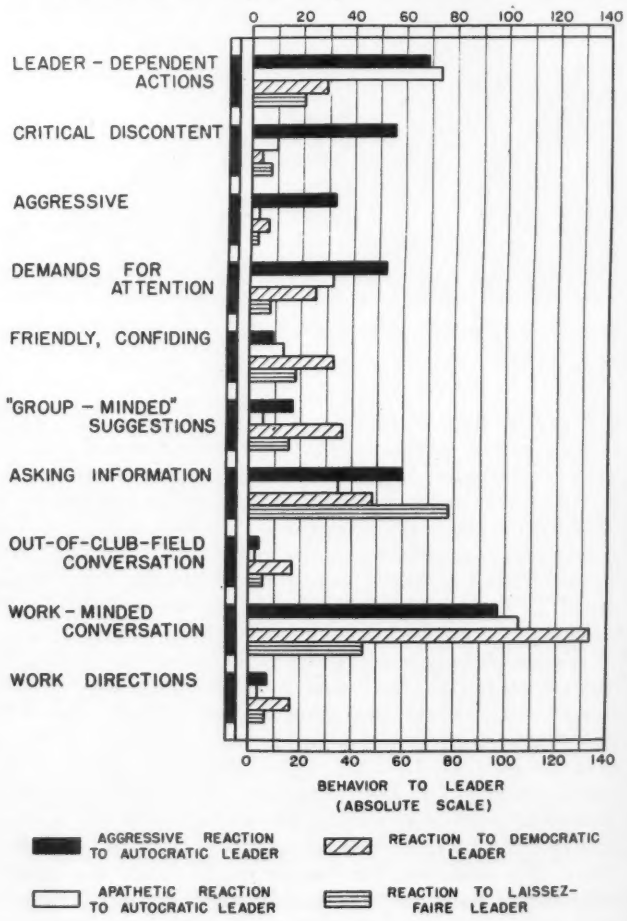
Science has led to engineering and the consequent reduction of human labor by the understanding of nature. In the past, engineering has tended to treat man mechanically wherever he came into the picture. The administration at M. I. T., realizing that industry does not function purely that way and that good management must realize that engineering does not operate in a social vacuum but rather has a great deal of influence on human culture, has initiated and supported programs dealing with the social aspects of engineering.

Being at M. I. T. not only gives the Center advantageous contact with the other sciences and industrial arts, but its central location also enables it to move with great freedom and work closely with many industries in carrying out field experiments in factories. In addition, the Center has the opportunity to study with little inconvenience almost all types of groups, minority, social, educational, and commercial, to mention only a few.

Along with field experiments conducted with natural groups around Boston, there will be laboratory experiments performed at the Center with artificially formed groups.

Arrangements exist between M. I. T. and Harvard University so that post-graduate students at either can attend classes at the other school. This enables the Center to take advantage of facilities not available at M. I. T. but found at Harvard, and in a reciprocal manner graduate students at Harvard whose studies cross the Research Center's field may attend classes at M. I. T.

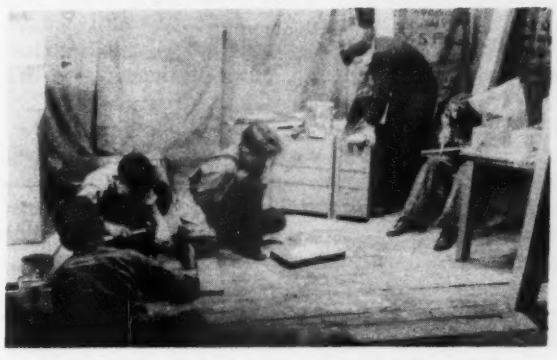
The Center is very young and still in the embryo



FOUR PATTERNS OF GROUP REACTION TO THE THREE DIFFERENT TYPES OF LEADERSHIP

This picture shows the boys working under a democratic atmosphere with the leader present

This club was under an autocratic atmosphere



Here the leader of the democratic club has left the room. The boys are continuing on their own

When the leader of this autocratic club left the boys alone for a few minutes, they forgot their work and started fooling

state. At present it consists of five members of the instruction staff at M. I. T., two research Fellows, and a number of graduate students, but plans exist for considerable expansion not only in the size of the staff but in increased space at M.I.T. This expansion waits only on some of the war research which is to vacate from buildings at the back of the Institute and give space to the Center.

Dr. Lewin views the immediate fields ahead which the Research Center will investigate as including these categories: leadership forms and social atmosphere; leadership training; production; group decision; public opinion measurement; and minority problems. While projects in many of these fields are already under way, none has been completed, so it might be wise to look at some experiments in group dynamics carried out prior to the Center's foundation by men now on the staff of the Center.

Perhaps the most interesting and informative example, both in the method used and the results obtained, is Ronald Lippitt's experimental study of the effect of democratic and authoritarian group atmospheres. The aim of that research was to study the influences which such experimentally induced group atmospheres would have both on the group as a whole and the individual members.

The groups studied and contrasted consisted of five members of grade-school age. These clubs, which met at the school during lunch hour, had a particular project in mind, namely, mask-making. Lippitt considered group atmosphere in terms of these factors: (1) nature of the group activity, (2) physical setting, and (3) social factors, such as the group and its properties, the position of the group in the larger social field, and the individual characteristics of the group members.

After the clubs had gotten under way the main purposes of each, originally identical, were permitted to vary. Group ideology was another variable along with style of living. These three went to make the large variable of a democratic as contrasted with an autocratic way of life.

Since the position of the club in the larger social field would have an effect, an attempt was made to have the authoritarian atmosphere as much more autocratic than the schoolroom as the democratic one was freer than the schoolroom.

It was found for the clubs studied that: (1) When given a chance, authoritarian group members attempted to deflate the leader. (2) A barrier did not develop between the democratic leader and his club members the way one did in the authoritarian atmosphere. (3) The individual in the authoritarian group was inclined to set up his own goals in conflict with the group goals in an attempt to gain social status. (4) There was more group spirit and "we-centeredness" under democracy than under autocracy where "I-centeredness" increased. (5) In the absence of the leader the autocratic group structure tended to disintegrate. (6) Authoritarian club members had a propensity to attack the weakest member among them as another means of gaining social status.

Additional studies have been made which give equally interesting results. Further experiments in autocracy and democracy, with the addition of a third classification, laissez-faire, showed that group-produc-

(*Continued on page 326*)

THIS IS M·I·T·

Electrical Engineering

By H. L. HAZEN
Professor of Electrical Engineering

WHY do forty per cent of all of those currently inquiring about admission to M.I.T. think they would like to become electrical engineers? Of the possible answers to this question we must not overlook the effects of publicity. Things electrical have had an extraordinary "press" during the war, especially since the veil of security has been lifted from many of the

Professor Hazen

war secrets. Radar and the proximity fuse, two of the reputed "big three" of the war's technical achievements, are electrical. These two developments with an electrical fire-control computer formed a team which paralyzed the serious threat of V-1, and speedily extinguished what little ardor remained in the Luftwaffe. At the earliest opportunity those who produced these electrical devices blazoned their advertising space with the wonders of Electronics, in terms suggestive of patent medicine vendors of pre-food-and-drug-act days. We all know the pattern. Aladdin's lamp had feeble powers in comparison.

Aside from this extraordinary press, electrical devices fascinated many who lived with them daily in the Services. Electrical gadgetry, much of it pretty sophisticated to be sure, appeared to be almost magic, and had the power to charm.

Is this charm only skin deep, or does there lie beneath it value and substance that can sustain satisfying professional careers? This is an important question to all who have come under the spell of electrical wizardry. The answer is that electricity offers professional opportunities of a high order to those having suitable qualifications.

What are these qualifications? Electricity is elusive; no one has ever seen it. Fortunately the utter chaos of radio signals which perpetually fill all space about us troubles us not unless we use a radio set, or our neighbor does. Being thus intangible, invisible, and usually unperceivable except through specialized instrumentation, electrical phenomena are fully comprehended only by those who find little difficulty in abstract or theoretical thinking or those who can use their imaginations to form visualizations of what happens to electrons, fields and electromagnetic waves in free space. Possession of this quality is one qualification for success in electricity.

Another qualification grows out of the generally well-behaved nature of electrical phenomena which lend themselves exceptionally well to mathematical treatment. So well indeed does mathematics portray electrical behavior that one without some flair for mathematical thinking had better seek another profession. A third qualification — one not peculiar to the electrical field and of controlling importance — is that the aspirant shall have those attributes of character and of person that are prerequisites of accomplishment in any human endeavor.

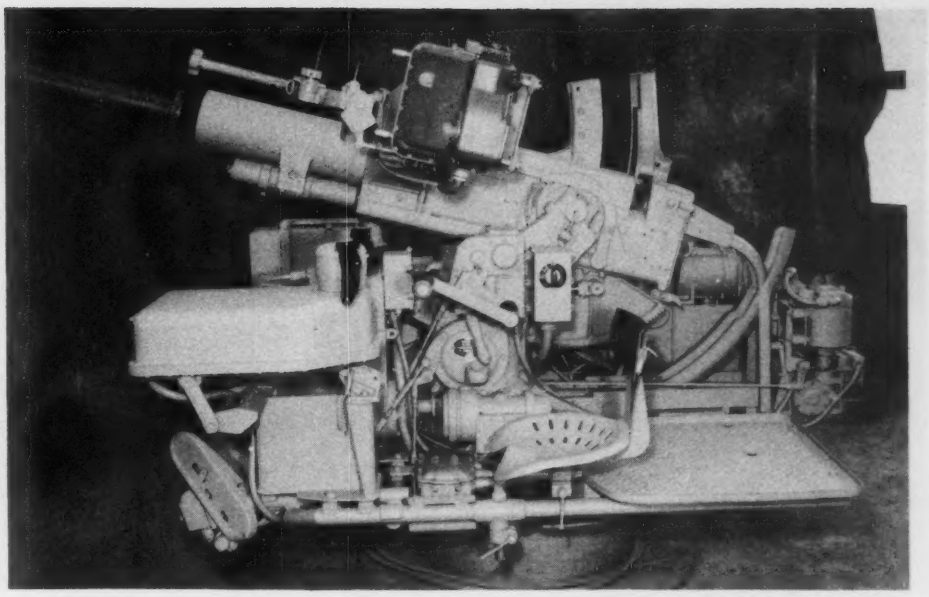
Admitting that at present Electrical Engineering has glamour in the eyes of many, how much of it is glamour and how much is substance? In terms of peace-time uses, radar is probably nine-tenths glamour, but the remaining tenth is very important in air and sea navigation. Television is very glamourous to judge from the subjects usually portrayed by its sponsors, but it too has substance, for the hard-headed directors of numerous companies are sinking millions of dollars to establish their stake in commercial television.

Electric power? Technically this is a well established and relatively mature field. Still, half-megavolt transmission, now in active development involves some first-class brain teasers. Comprehensive system planning, using electrical network analyzers, is just now becoming widely accepted practice. In industry, electric power takes new and varied forms as process manufacturers see lower prices and higher profits resulting from faster and more precisely controlled drives. Electric power requirements for airplanes are forcing many kilowatts of machine capacity into space and weight hitherto needed for one-tenth these outputs.

In the student's mind the electric power field has recently become so overshadowed by the glamour of electronics that the relative opportunities may well become favorable to the power man during the coming decade. Thus in the power field we have a modicum of glamour with much substance.

In measurement and control functions generally, and quite independent of the kind of physical quantity being measured or controlled, the tremendous power and versatility of electrical techniques makes them well

nigh universal in application. Concretely, nature endowed electrical techniques with three valuable attributes: first, extreme sensitivity; second, tremendous magnification; and third, flexibility or versatility in conversion from and to other forms of energy. Considering the first quality, sensitivity, power of the order of 10^{-16} (0,000,000,000,000,000,1) watt is easily detectable; with real care, the figure is nearer to 10^{-20} watt. As an illustration of the second quality, magnification, we may cite the over-all amplification used in a land-cable and ocean-radio telephone link from New York to Australia which is roughly 10^{100} in power. This magnification, in many stages to be sure, is sufficiently free from aberration or distortion so that a voice is easily recognizable when transmitted over this system. The third quality, flexibility of conversion to other forms of energy, is apparent when we observe that the energy of sound, of light, of mechanical motion or displacement, of chemical combination, or of heat is easily converted to electrical form, and vice versa. With such a bag of tricks at his disposal the electrical engineer or physicist need have little hesitancy in tackling almost any problem involving physical measurement.



Electrical Engineering Department

40 mm. gun mount, from the pointer's side, showing part of the maze of servomechanisms used to control the elevation and traverse in conjunction with the Draper computing sight seen at the top. Much of the Electrical Engineering Department's war work was done along the lines of servo development

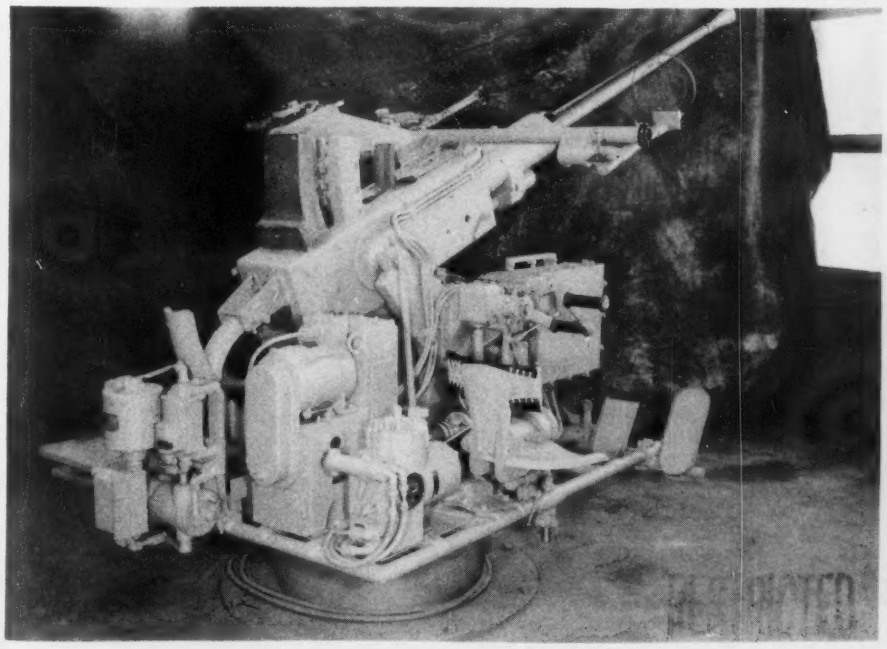
The qualities just emphasized, plus an equally important fourth — very high speed of propagation of electrical effects in space — leave electrical methods almost without competition in rapid communications. Mails or messengers do have a place for slow and low-cost or high-security communication, but the electrical methods of telephone, teletype, telegraph, facsimile and television, through space or over wires: or of radio broadcasting, radar, and navigational aids are replacing these physical transport methods and are also creating vast new uses of long-distance transfer of intelligence. War developments have enlarged by at least thirtyfold the frequency space available for radio communication functions. Constructive exploitation of this great new resource will keep many engineers busy for years. Surely in the communications field as well as in that of measurement and control we have substance — as well as glamour — for the oncoming engineer.

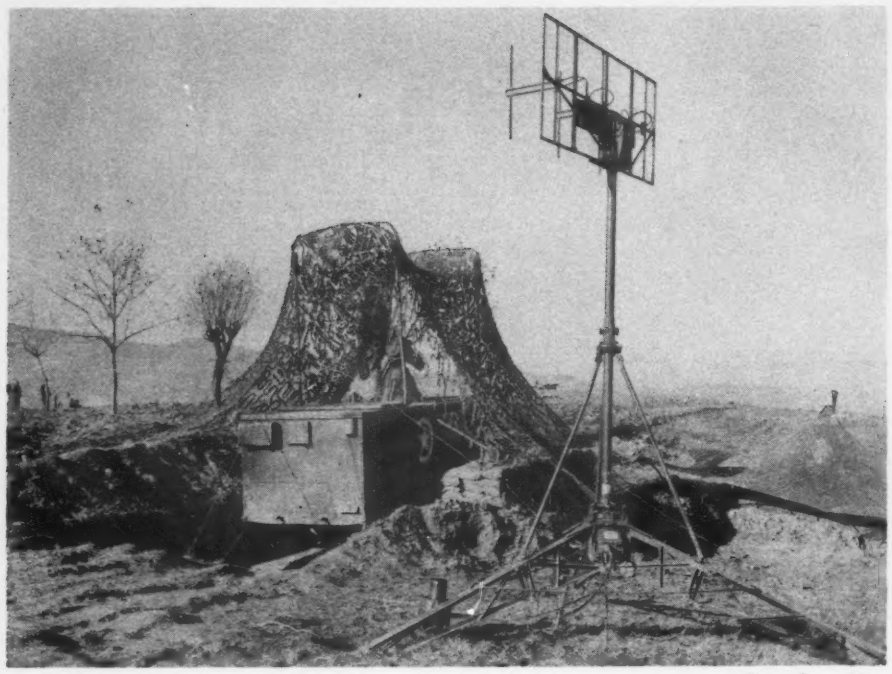
What of M. I. T. in this picture? The briefest statement of a philosophy and a mere listing of a many-sided program must suffice to answer this question here. The philosophy has two principal tenets. First, the solution of new problems and the new solution of old problems represent more pressing needs, constitute a more difficult activity, require rarer talents and at the same time are more satisfying endeavors than the routine application of known solutions. Second, the more novel the problem, the more fundamental, broad, and imaginative is the approach required to obtain a solution.

In terms of Electrical Engineering, these tenets require emphasis on mathematics and physics at a level of mastery that makes them daily working tools. Probably the toughest discipline in engineering education is the ability to think through a physical problem with the clarity and exactness to permit effective use of mathematics. If one has achieved the rigor of thought and depth of understanding whereby he can formulate accurately the differential equation of

A view of the 40mm. mount from the Air Power Unit Side

Electrical Engineering Department





Signal Corps Photo

Another phase of the Department's war work — radar. Here gun-laying radar (left) and identification radar (right) are set up for use in Italy

a new application of electricity or mechanics he has acquired the most important single element of the scientific approach to creative engineering.

Scientific breadth — not to be confused with superficiality — is likewise important. An engineer characterized by original achievements almost always shows a surprisingly firm grasp of classical physics in addition to especial facility in the area of his partcular specialty. In addition to the classical physics the future undoubtedly calls for at least an elementary command of "modern" physics.

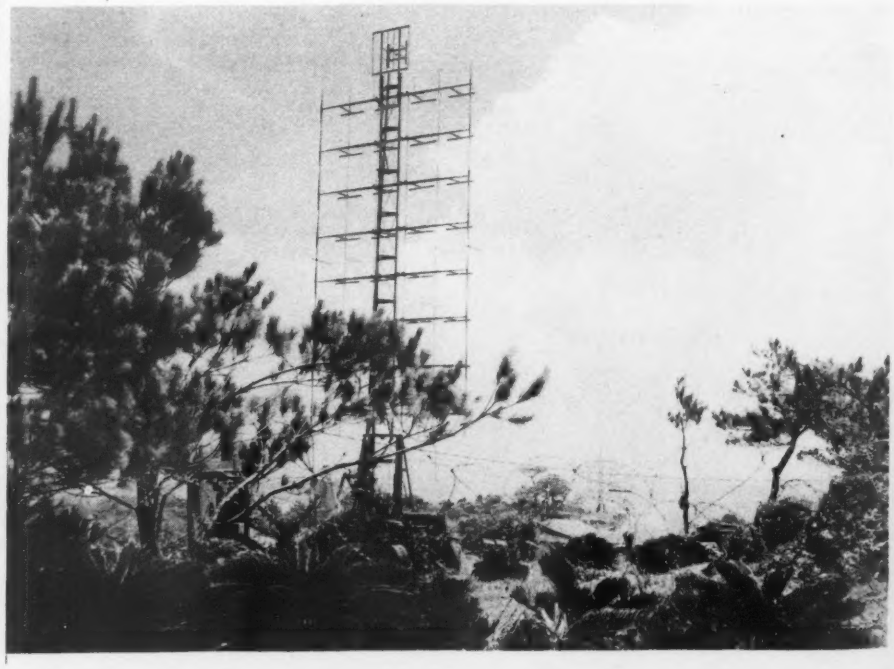
One other part of the philosophy, and one even more difficult to implement than the scientific stem, is that the engineer should be a man among men as well as a technical man among his like. He must have bonds of sympathy and interest with other men ranging well outside his professional area if he is to actuate the human forces that motivate accomplishment. Logic may occasionally guide, but it certainly does not energize the doings of men.

Finally, it is elementary, but too often ignored by even the "communication" embryo engineer, that communications in the broad sense is really important. He wants training in his communications circuits, but fails to see that communications implies conveyance of ideas, and that ideas are conveyed by written or spoken words. He worries inordinately about the fidelity of his audio circuits and grimaces at distortion in his radio receiver. At the same time he is blandly insensible to the distortion contained in a badly written report, distortion so bad that the entire results of a year's work may be unintelligible at the "receiving end" in the form of a boss or client.

Implementing this philosophy, the electrical-engineering curricula emphasize mathematics and physics and their applications to engineering problems. While distinct branches are provided for power, electronics, and communications, the over-all differences are not great. They serve as varieties of flavor to stimulate different appetites rather than as actual specialization. For those who wish to incorporate coördinated industrial practice within their academic program the Coöperative Course offers exceptional opportunity leading to both the Master's and Bachelor's degree at the end of five years. The Graduate School, exceedingly active at present, offers advanced work leading to either the S.M. or Sc.D. degree. Paradoxically, the so-called advanced work is probably more nearly a means of forcing better and deeper understanding of fundamentals than a specialization.

Coupled with the Graduate School and serving as a leaven to both staff and graduate students are a number of very active research programs carried out in a variety of laboratories. Illustrating an important and welcome trend away from compartmentalization, particular interest centers around three research laboratories in which the Electrical Engineering Department has joint interest with other departments. These are the Research Laboratory of Electronics, joint with Physics; Acoustics Research Laboratory, joint with Physics and Archi-

(*Continued on page 324*)



A mobile early warning radar set in use on Okinawa. Note the smaller identification radar antenna atop the main radar

Bearings

By *ALVIN SITEMAN, 2-48*

FRICTION has worked both for good and for evil since the beginning of civilization. Early man took the first step towards the reduction of friction when he substituted rolling for sliding friction. Oil films consisting of layers of minute globules which hold surfaces apart were next used in man's fight against friction. The reduction of friction losses in machinery has become increasingly important within the past two hundred years. The best anti-friction devices yet designed for machines are bearings of many different types and weighing anywhere from one ounce to four or five tons. Bearings are used in automotive vehicles, railroad equipment, and industrial machinery to prevent wear, increase the accuracy of the machines, reduce maintenance, resist loads from all directions, permit higher speeds, simplify design, and to allow accurate interchangeability.

Most bearings have four principal parts:

(1) A "cone" or inner race which fits over the shaft or spindle.

(2) A "cup" or outer race which fits inside the wheel hub or other carrier.

(3) A series of "rollers" or balls which revolve between the cone and the cup.

(4) A "cage" or other device to keep the rollers or balls in position between the cup and cone.

There are many different bearing designs, but about five main types. CUP-AND-CONE BALL BEARINGS sacrifice radial (vertical) load capacity because the cup and cone are set at an angle in order to resist end-thrust (side loads). In this type of bearing the slightest wear of the ball race ruins the bearing. ANNULAR BALL BEARINGS have a sufficient radial load capacity, but they must be larger than a roller bearing because the latter carries loads along the full length of rolls. The end-thrust capacity of this bearing is very low. The BALL THRUST BEARING carries thrust loads only and is used to supplement annular ball bearings where thrust loads are encountered. STRAIGHT ROLLER BEARINGS have a large radial load capacity, but no capacity for thrust loads. These bearings must be used with thrust bearings. TAPERED ROLLER BEARINGS have a larger radial load capacity than ball bearings and the tapered construction gives it capacity to carry end-thrust loads.

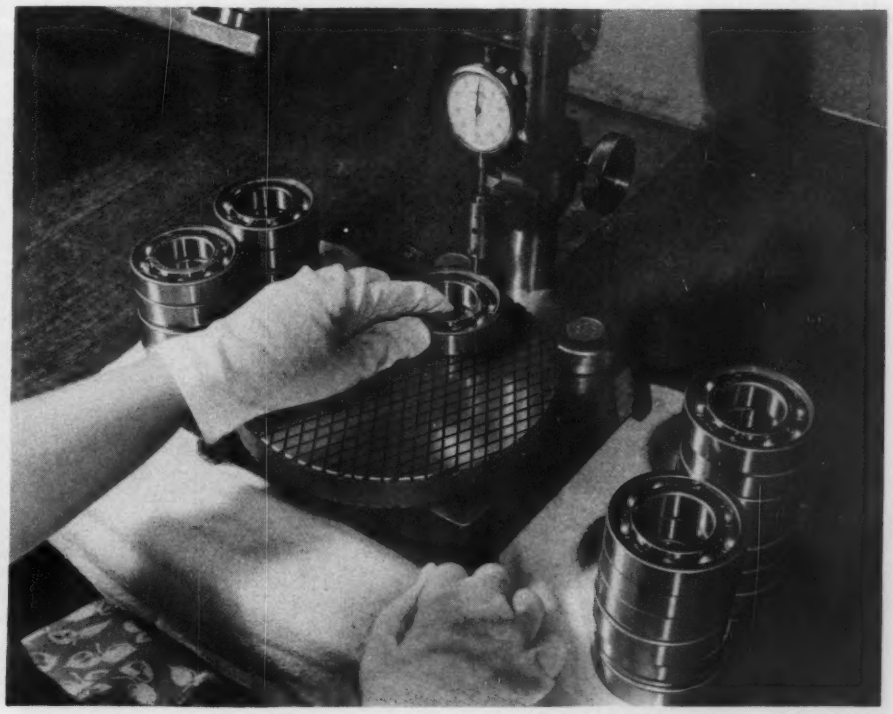
The manufacture of tapered rolls is a relatively simple process as it is done by Timken. Solid bars of steel are finished automatically in roll-turning lathes which taper the steel rolls. Rolls, cups, and cones receive their wear-proof surfaces by carburizing in rotary furnaces. Automatic spindles are used for shaping specially treated seamless tubes into bearing cones and cups. When the parts are hardened, oil pours into the quenching machines to assure uniform hardening. The bearing cages are stamped out of strip steel in heavy presses.

New Departure manufactures ball bearings from steel treated much the same as in the Timken processes. A high carbon chrome alloy steel is made into the form of rods and coils which are annealed. Most of the scale on the rods is removed by passing the rods through rolls and the remaining scale is removed by a dilute sulphuric acid pickling solution. The wire is then washed and neutralized in a hot lime solution which serves to prevent rust. To achieve uniformity of diameter the wire is drawn through tungsten carbide dies, thereby slightly reducing the wire size.

In forging (either hot or cold) the wire is fed through a cut-off die where a slug is sheared off and formed roughly round between hemispherical dies. Careful control prevents flash, which is the excess metal forced out between the dies. This forging process causes internal stresses which are eliminated by heat treating or normalizing in special furnaces, after which the balls are allowed to cool slowly to room temperature. The balls are rough ground in machines which hold the balls against the side of a grinding wheel with a pressure plate. The direction of ball rotation is opposite to that of the wheel and the balls emerge a few thousandths out of round.

To carry heavy loads the balls must be hard and tough. After being heated to the correct temperature, the balls are quenched in oil or water. The balls are then passed between stationary and revolving plates where a mixture of oil and fine abrasive finish grinds them. Finally the balls are polished with soluble oil, water, cutting compound, and unfused alumina and then finished by polishing with leather in tumbling barrels. New Departure tests its steel balls under a

Gauging ball bearings for width — *New Departure*



pressure of ninety tons by driving a ball into a steel block with a hydraulic ram.

New Departure developed preloading as a method designed to increase the machine accuracy of its ball bearings. If a predetermined load is applied to a bearing before the external or work load is imposed, the deflection due to the work load would be a great deal less than if no preload were used. Preloading is adaptable only to axial (or thrust) bearings and not to strictly radial bearings.

Thus it can be seen that bearings are made of the best steels and are accurately machined. It is necessary to have strong bearings in order that they can resist the many forces which are applied to them. Engineers have spent many years investigating the mechanics of bearings in order to discover how the best bearings can be made. If the manufacturer knows what forces act on a bearing and how they act, he can design bearings that will resist those forces.

The wide use of ball and roller bearings has resulted from the fact that rolling friction is less than sliding friction. Even though the resistance to rolling is small, it is a complicated phenomenon. No one has yet been able to develop a complete theory for calculating the rolling resistance under all possible conditions.

If two curved surfaces are in contact with each other under a load perpendicular to the surfaces at the point of contact, the resultant pressure deforms the material in both bodies to form a definite area of contact. As one of the almost perfectly elastic bodies rolls over the other, compression is increased on the forward parts of the contact area and reduced to the rear. The result of these forces is a resistance to motion. The difference in pressure for stresses within the elastic limit is dependent on the speed with which loading and unloading occur. The elastic properties are dependent on the temperature; therefore, the rolling resistance is influenced by temperature as well as by stresses and rolling speed. The magnitude of deformation of bearings is determined by the radius of curvature of the surfaces in contact and by the specific load in the contact area.

Tangential forces due to thrust loads or sliding friction between the surfaces develop elastic deformations which together with the perpendicular load cause bulges to form about the area of contact. If the rolling of one body is in the same direction as the tangential force on the support, the rolling resistance will increase. On the other hand, the resistance is decreased if rolling takes place in the opposite direction to the tangential force.

Loss of energy due to sliding friction is a large part of the rolling resistance and is equal to the total of the product of sliding friction force and sliding distance, summed over all points of the contact surface. This loss is influenced by lubricant properties in addition to the stresses mentioned above.

To summarize, rolling resistance is influenced by elastic properties, condition and shape of the surfaces, magnitude of the loads, speed of rolling, temperature, and the condition of the lubricant and atmosphere. In a bearing these losses result from the curved shape of the contact surfaces and contact between the rolling elements and the cage. Tests have shown that a simple formula may be used to compute the friction torque (M_f) in a bearing:

$$M_f = M_0 + f_F \cdot F^c$$

where M_0 is the torque at zero load

f_F is a coefficient dependent on the size and design of the bearing

F is the equivalent radial or thrust load and

c depends on the type of bearing ranging from a value of 1 to 1.7 for common bearings.

When a ball bearing is under zero load on a curved support, the contact between the surfaces is a point. When a load is applied to the bearing, this contact changes to a circle or an ellipse. In the case of roller bearings the contact between the race and the rolling element is a line when the bearing is under zero load. Under a load the contact becomes a trapezoid or rectangle. The stresses are obviously the cause of the

Forging bearing parts — *New Departure*

Machining bearing cups

New Departure

deformation. The compressive stresses are highest at the surface, but the shear stress, which causes breakage or cracks, develops inside the elements at a certain small depth under the surface. Through the use of Hertz' theory for "Contact of Elastic Solids," it is possible to calculate stresses, deformations, and contact areas within bearings. This information is important to the manufacturer as his product must be as efficient as possible. Only the best steels can be used to make the bearings which must withstand continuous and varying strains. If the elastic limit of the material composing the bearing is passed, permanent deformation will occur. This permanent deformation usually occurs with one-third in the rolling element and two-thirds in the ring. Fractures do not occur until the permanent deformation has assumed considerable proportions; therefore, the manufacturer does not have to consider fractures as a large permanent deformation would ruin a bearing anyway.

Since external forces acting on a bearing are transmitted through the rolling elements from one ring to the other, the distribution of the forces among the individual rolling elements is dependent upon the elastic deformation of the bearing parts. Calculation of the actual load distribution is of importance only in static cases where the bearing does not rotate under load. The maximum load per ball in a radial ball bearing is given by:

$$Q_{MAX} = 5\frac{F_r}{z}$$

where F_r is the radial bearing load and
z is the number of balls in the bearing.

This formula varies considerably by functions of the angle at which the load is applied. The constant term also varies between two and eight for different types of ball bearings.

When a centered load acts on an axial or thrust bearing, the load on each rolling element is:

$$Q = \frac{F_a}{z \sin \alpha}$$

where F_a is the centered thrust load
z is the number of rolling elements in the bearing and
α is the contact angle.

Again the formula varies considerably for different types of thrust bearings.

When a rolling element moves in a rotating bearing, it exerts a centrifugal force on the rings, given by:

$$K = \frac{G}{g} r_m \omega_m^2$$

where G is the weight of the rolling element
g is the acceleration due to gravity
r_m is the bearing pitch radius and
ω_m is the angular velocity of the set of rolling elements.

The centrifugal forces are small and do not reduce the load-carrying capacity of the bearing except at high speeds where the capacity may be reduced by 10 per cent.

In ball and roller bearings the rolling elements change the direction of their axes of rotation if the contact angle is not zero ($\alpha > 0$) and gyratory forces will then exist. The gyratory moment M_d is given by:

$$M_d = I \omega_w \omega_m \sin \alpha$$

Inspection of balls for use in bearings

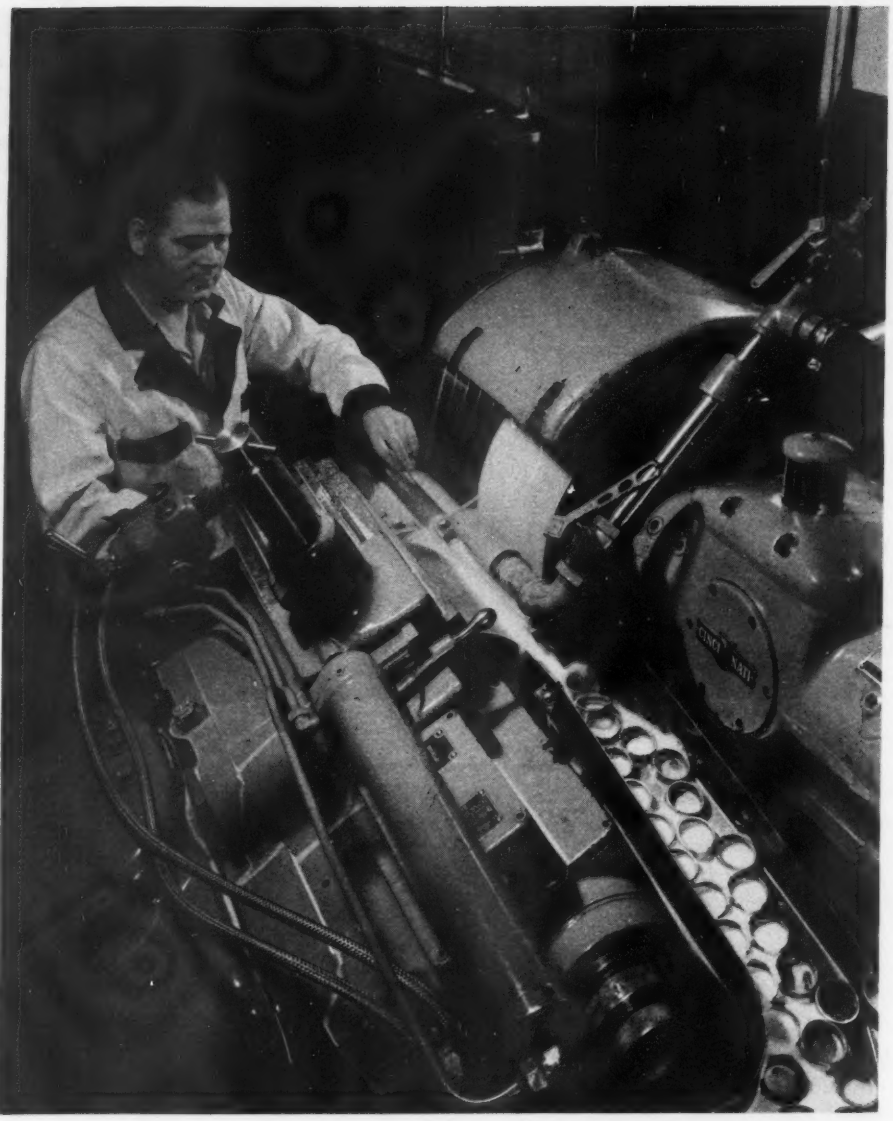
New Departure

where I is the mass moment of inertia of the ball
ω_w is the angular velocity of the ball about its own axis, and
ω_m is the angular velocity of the ball center about the bearing axis.

The formula shows that the gyratory moment increases with the contact angle which is the highest in pure thrust bearings where $\alpha = 90°$. The contact angle is always measured from the vertical. The spinning of the ball in the direction of the gyratory moment is resisted by the friction moment caused by the ball load. Where sliding and rolling occur at the same time, the coefficient of friction is 0.07 to 0.08 for low rolling speeds. However, at high speeds this friction coefficient may be as low as 0.02 due to the formation of a lubricant film. The requirement for sliding not developing is that the friction torque (M_F) is greater than the gyratory moment (M_d). This means that the thrust load on the bearing (F_a) must be greater than $5.75 \cdot 10^{-12} z d_m D_w^3 n^2$, where z is the number of rolling elements
d_m is the mean diameter of the bearing bore
D_w is the ball diameter and
n is the speed of rotation.

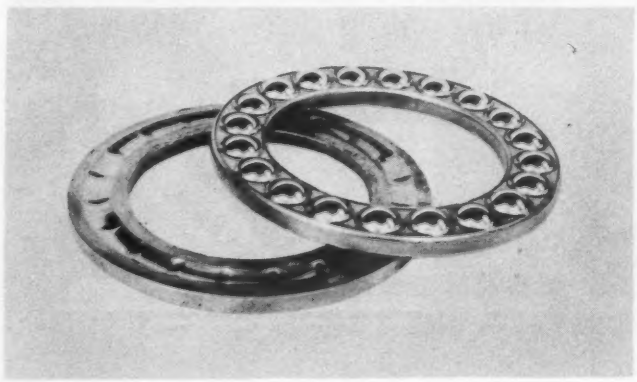
It is very difficult to make sure that the load will not go below the value which is required to prevent sliding due to the gyratory moment. It is fortunate that sliding between surfaces due to the spinning of the ball in the direction of the gyratory moment, does not have a damaging effect on the bearing, if the specific load on the balls is less than 0.008 kg/mm² and the lubrication is good.

It is obvious that gyratory forces exist in all radial bearings which have a contact angle greater than zero, but they are so small that sliding can develop only when the ball load is so low that the bearing surfaces can not be damaged. In roller bearings with $\alpha > 0$, the gyratory moments only cause a slight change in the load distribution in areas of contact.



Grinding the outside diameter of cups — *New Departure*

Cavity formation due to foreign particles pressed between the rolling elements and the rings — *SKF Industries, Inc.*



Bearings cannot be expected to give unlimited service. If they are protected from dirt and moisture, well lubricated, and properly handled with respect to loads, only metal fatigue causes a crack to appear on the load-carrying surfaces and it cannot be avoided. However, the number of revolutions that a bearing makes before this "flaking" starts is a function of the bearing load. The "life" of a bearing is that period of service which is limited by metal fatigue and it is measured in number of revolutions or in number of hours of operation at a certain speed of rotation. Tests have shown that the longest life seldom exceeds four times the average life, and that 90 per cent of the bearings have a longer life than one-fifth of the average. It is possible to show that the material stress which 90 per cent of the bearings can endure for a given length of time is only 16.5 per cent smaller than that stress which can be endured for the same length of time by those bearings which have a life in excess of the average. In view of these facts, the "estimated life" is defined as that number of bearing revolutions, or that number of working hours at a certain speed of rotation, which will be reached or exceeded by 90 per cent of all bearings. The average life (L_m) will be about five times as long as the estimated life (L).

If one group of bearings of a certain type and size

(*Continued on page 310*)

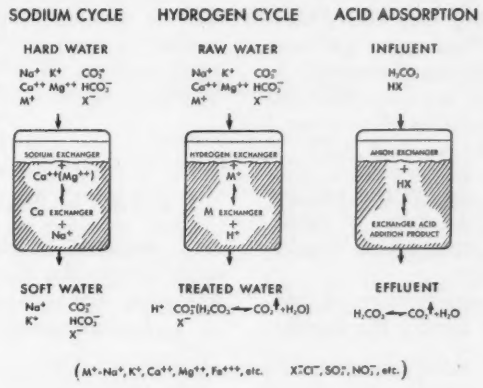
Ion Exchange Resins

Part I

By KENNETH WIBERG, 2-48

ONE of the most important modern developments of the chemical process industries has been the development of the ion exchange resins. These materials have played an important part in the development of several industries and in the advancement of many others.

The chemical phenomenon of ordinary cation exchange is exhibited by several naturally occurring sodium aluminum silicates, whereby calcium and magnesium ions in water are replaced by sodium ions, is well known and has been used for many years in softening water for industrial use. The naturally occurring silicates (greensands or zeolites) first used were improved by chemical treatment in some cases, while in others, synthetic zeolites with higher exchange capacities were developed. These inorganic materials have been suited for application where decrease in hardness is the main requirement. However the total solid content must be higher on the basis of chemical equivalencies than that of the raw water.



Exchange processes

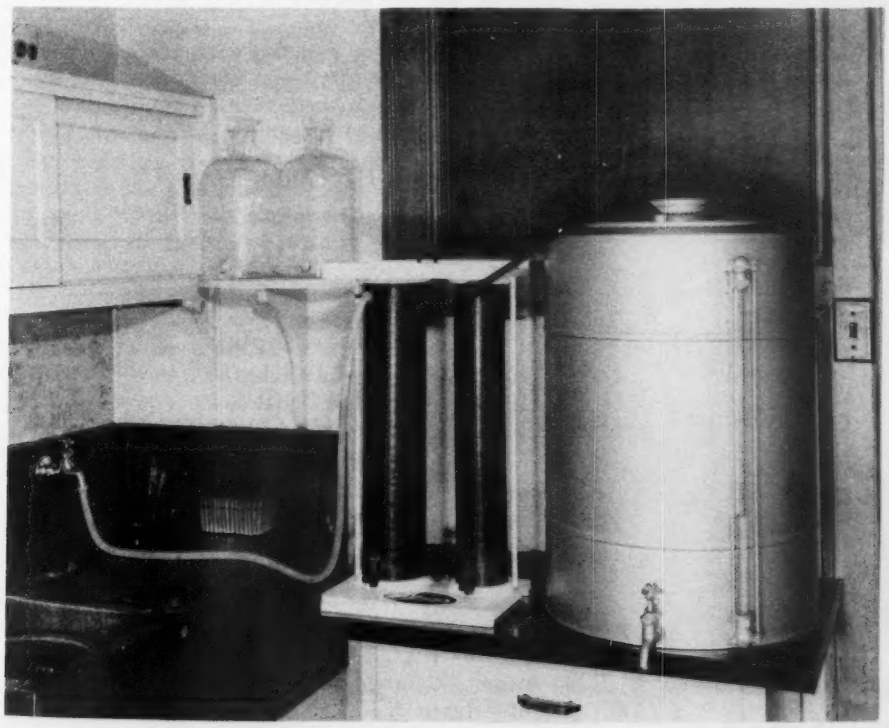
The Resinous Chemical and Products Co.

It can be seen that if the raw water has a high carbonate or bicarbonate content, the alkalinity of the resultant water is likely to be excessive. Since excess alkalinity is responsible for an increase in the amount of silica extracted from the zeolite beds, a probable increase in the danger of embrittlement in boilers, and "snowy" ice in ice manufacture, the disadvantages of such a method are obvious.

The so-called "carbonaceous zeolites" were developed about 1930 because of the necessity for obtaining a material which would exchange all cations by hydrogen ions. The hydrogens of the sulfonic acid groups in the carbonaceous zeolites generally prepared by the sulfonation and oxidation of complex organic materials, such as wood, coal and lignite, similar to the sodium atoms in a zeolite are exchangeable, and, in fact, will exchange with all cations. The exchange of hydrogen for all cations leads to a reduction in the total solids as well as a reduction in the hardness. Regeneration is effected by treatment of the exhausted exchanger by means of hydrochloric or sulfuric acids, and the exchanger is spoken of as operating in the "hydrogen cycle." Carbonaceous exchangers have developed rapidly and are employed in a variety of ways in water purification.

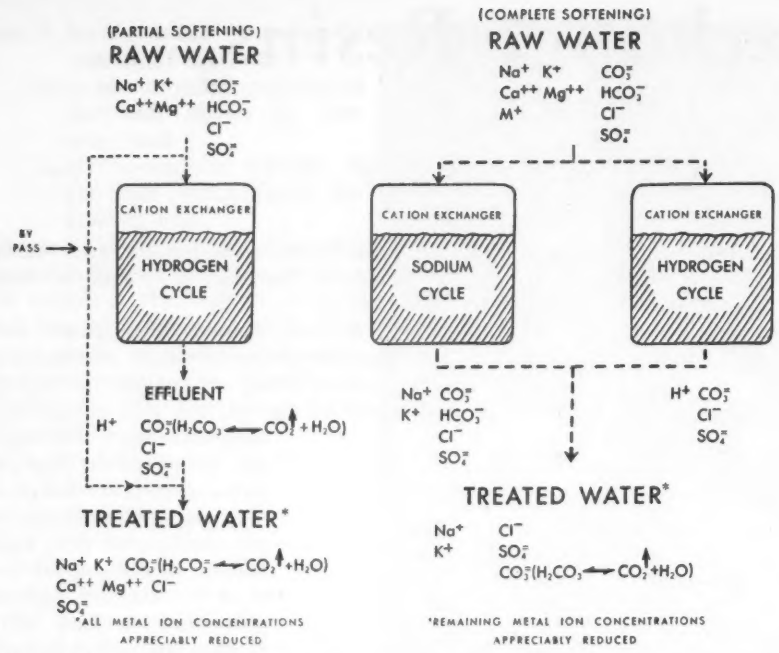
The discovery of Adams and Holmes is 1935 that ion exchange properties are possessed by synthetic resins of certain composition has opened the door to incalculable opportunities, since these ion exchange resins may not only be used in all applications in which the carbonaceous exchangers have hitherto found employment, but, in addition, have the added properties of a very high efficiency and a high capacity. It is possible to select the materials used in the preparation of the resin so that modifications can be "tailor-made" for a particular application. These compounds are the so-called "resinous base-exchangers" or "ion exchange resins."

Adams and Holmes also reasoned that an amine-formaldehyde resin would be capable of removing acids from solution by virtue of the presence of the basic amino group in the polymerized resin. The polymerized amine-formaldehyde resin is used to remove hydrochloric and sulfuric acids from solution, and the resin may be regenerated with alkaline



Twelve gallons per hour — 1500 grain removal laboratory model water treater complete with storage tank.

Illinois Water Treatment Co.



solutions. It can be seen that the use of the cation exchange resin in connection with this type of resin would lead to the production of a water which would favorably compare with distilled water.

In order to fully appreciate the significance of this development, it is necessary to review briefly the fundamental principles of the ion exchange process. There are two types of ion exchange resins in commercial use — the cation exchanger and the anion exchanger or acid adsorbent. The use of these materials in softening water or in removing salts from aqueous media is illustrated by the equation (bottom right column).

It can thus be seen that the cation exchanger resin acts as either a sodium or hydrogen exchanger, depending upon the application conditions. The passage of the raw water through the double system of cation and anion exchangers yields a water which is comparable and often superior to distilled water (see Table 1). Such units are commercially feasible, and such "Deionized Water" units are finding wide use in industry. The results have been generally excellent (see table 2) but there is of course a limit of practicability. The resins are usually unsuited to water with over 500–1000 ppm. (0.05–0.10%) salt content.

These resins differ from other water conditioning agents in that they may be easily regenerated. The

ANALYSES OF 7 INDUSTRIAL DISTILLED WATERS & 7 INDUSTRIAL DEMINERALIZED WATERS

Distilled Water Plant	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Hardness as ppm $CaCO_3$	0	6	10	0	0	15	1
Alkalinity as ppm $CaCO_3$	13	9	18	5	4	12	2
Sulfates as ppm SO_3	0	0	0	2	3	5	1
Chlorides as ppm Cl	4	0	0	2	1	2	0
Total salts as ppm $CaCO_3$	19	9	18	11	9	21	3

Demineralized Water Plant	*H*	*I*	*J*	*K*	*L*	*M*	*N*
Hardness as ppm $CaCO_3$	0	0	0	0	0	0	1
Alkalinity as ppm $CaCO_3$	3	2	3	4	6	2	4
Sulfates as ppm SO_3	0	0	0	0	1	0	1
Chlorides as ppm Cl	0	0	0	0	2	0	0
Total salts as ppm $CaCO_3$	3	2	3	4	9	2	5

Table 1

Table 2. Results of deionizing taken from Industrial Installations. (All analyses are ppm. as CaCO³)

PLANT	A		B		C	
Water	Raw	De-ion	Raw	De-ion	Raw	De-ion
Calcium & Magnesium	128	0	166	0	427	0
Sodium	6	0.2	83	0.2	128	2.0
Total cations	134	0.2	249	0.2	555	2.0
Bicarbonate	110	0.2	145	0.2	292	2.0
Chloride	9	0	30	0	42	0
Sulfate	15	0	74	0	221	0
Total anions	134	0.2	249	0.2	555	2.0

Heavy Metals in Solution are Reduced to a Concentration of 0.01 ppm or less

Reduction of alkalinity

The Resinous Products and Chemical Co.

method used will be obvious after an examination of the above equations. As each is a reversible reaction, it is only necessary to supply an excess of the products to cause the reactions to reverse themselves and thereby regenerate the original materials. However it is not usually economical to completely regenerate the resins, so that an optimum regenerationvalue is chosen.

Although the mechanism of the anion adsorbent is thought to be different, regeneration can likewise be effected. Treatment of the depleted anion resin with sodium carbonate solution neutralizes the acid which has been fixed and frees the anion exchanger for further acid adsorption.

$$2\,RX.HCl + Na_2CO_3 \rightarrow 2RX + 2NaCl + CO_2 + H_2O$$

Compared to the other exchange materials previously available, the ion exchanger resins possess the following advantages:

1. Excellent stability, both chemical and mechanical as evidenced by superior resistance to acid, heat, and mechanical abrasion or attrition. Because of the non-rigid gel structures which these resins possess, they are much more resistant to mechanical breakdown which

Cation Exchange Resin

Sodium Cycle

$$2NaR + CaSO_4 \longleftrightarrow CaR_2 + Na_2SO_4$$
$$2NaR + MgCl_2 \longleftrightarrow 2NaCl + MgR_2$$
$$2NaR + Ca(HCO_3)_2 \longleftrightarrow CaR_2 + 2NaHCO_3$$

Hydrogen Cycle

$$2HR + CaSO_4 \longleftrightarrow CaR_2 + H_2SO_4$$
$$2HR + MgCl_2 \longleftrightarrow MgR_2 + 2HCl$$
$$2HR + Ca(HCO_3)_2 \longleftrightarrow CaR_2 + H_2O + CO_2(gas)$$
$$HR + NaCl \longleftrightarrow NaR + HCl$$

NaR = Sodium salt of cation exchange resin.
HR = Hydrogen derivative of cation exchanger.

Anion Exchange Resin

Acid Removal

$$2\,RX + H_2SO_4 \rightarrow (RX)_2 . H_2SO_4$$
$$RX + HCl \rightarrow RX . HCl$$

RX = Anion exchange resin with the acid binding substituent X.

(*Continued on page 316*)

THIS IS M·I·T·

Naval Architecture and Marine Engineering

By THE STAFF OF THE DEPARTMENT

THREE fields of study are offered in the Department of Naval Architecture and Marine Engineering: an undergraduate Course in Naval Architecture and Marine Engineering (XIII), a three-year graduate Course in Naval Construction and Engineering for officers of the United States Navy, leading to the Master's degree (XIII-A); also a three-year graduate Course in Naval Construction (XIII-B), and a five-year undergraduate Course in Marine Transportation (XIII-C).

Course XIII, Naval Architecture and Marine Engineering

A large modern ship is man's most massive mobile structure. It is a structure that must resist the attack of more violent storms than most shore structures ever have to withstand. However, a ship is far more than a structure. It is a power plant, a hotel, and a means of transportation. It is, in fact, in many ways a complete city, and many passenger ships and naval vessels have power plants as large as moderately sized cities. It is a logical conclusion, therefore, that virtually all types of engineering must be involved in the design, construction, and outfitting of a large vessel. Not only are many branches of engineering involved in shipbuilding, but also most types of engineering materials are used in the building of a ship.

In view of the fact that the ship designer and builder must have some familiarity with most branches of engineering and with a vast number of materials, it seems evident that he should have the broadest kind of engineering training possible. The futility of trying to be a "Jack of all trades" is well understood; nevertheless, it cannot be emphasized strongly enough that Course XIII is intended to give a broad, solid foundation in the fundamentals of engineering, and not merely training in narrow technical specialties. It is true that the graduate of Course XIII, especially if he goes to work in a large shipyard, will eventually specialize in some phase of the industry. However, to handle his own specialty to best advantage and to coöperate with others in a shipyard most effectively, he must have some understanding of the problems of the rest of the yard. This becomes increasingly important as he works his way toward the top, acquiring more and more administrative responsibilities.

In Course XIII the professional subjects deal largely with the design of a ship and its machinery. The Course is not long enough to provide much instruction in the practical aspects of ship construction in addition to design; and it is felt that a knowledge of construction methods is more easily acquired after graduation than is a knowledge of theory and design. However, a good balance between the theoretical and practical aspects is maintained in the drafting room and in the problems assigned. Outside of the purely marine subjects in Course XIII most of the subjects are the same as those required by the Course in Mechanical Engineering.

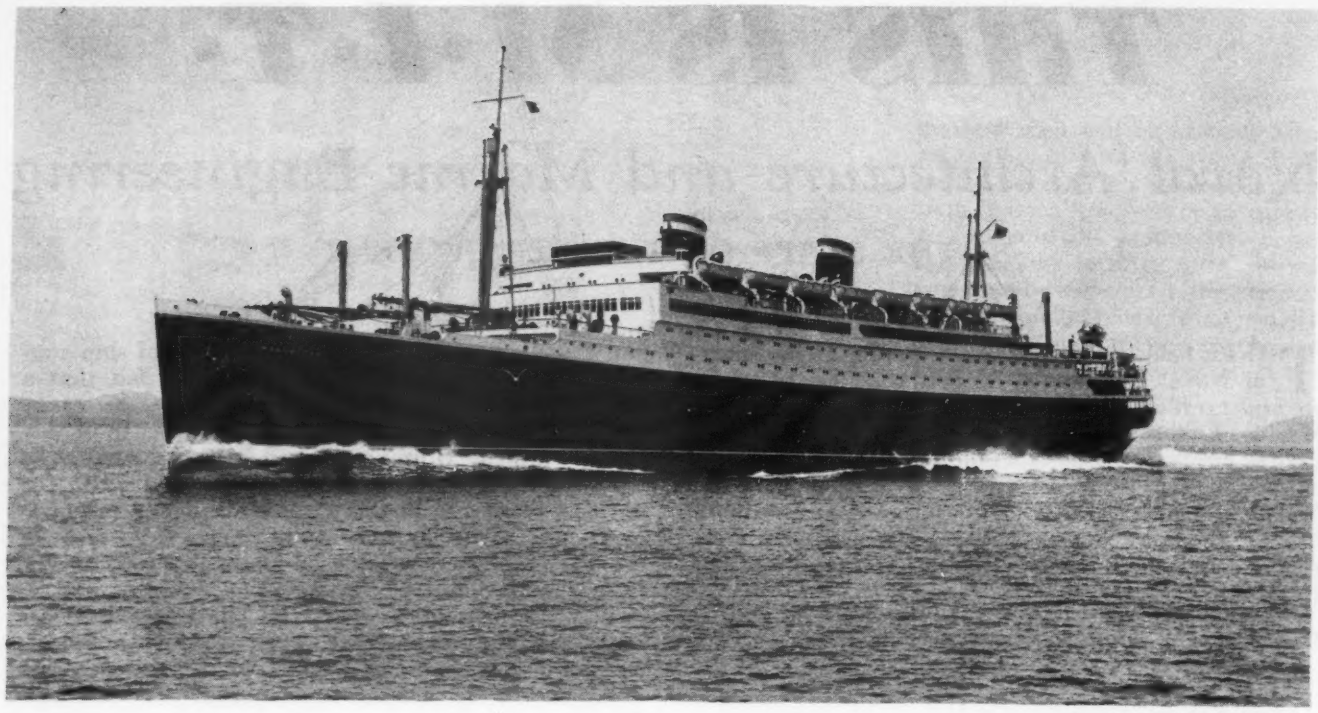
This history of Course XIII illustrates its close connection with Mechanical Engineering. Marine Engineering first appeared at M. I. T. in 1885 as an option of Course II, Mechanical Engineering. Six years later Naval Architecture appeared as another option of Course II. Naval Architecture became a separate department in 1893 under the direction of Professor Cecil H. Peabody, but it was not until 1910 that the Department was given the dual name of Naval Architecture and Marine Engineering.

In 1920 the present building occupied by this Department was erected from the bequest of Mr. Charles H. Pratt and the name Pratt School of Naval Architecture and Marine Engineering was adopted.

Shipbuilding in this country has fluctuated a great deal in the past fifty years with the result that the demand for technically trained men in this field has had its ups and downs. However, there are only two other American schools which give complete courses in naval

Bethlehem Steel Co.

A typical shipyard at night. The battleship "Massachusetts" is in the ways



New York Shipbuilding Co.

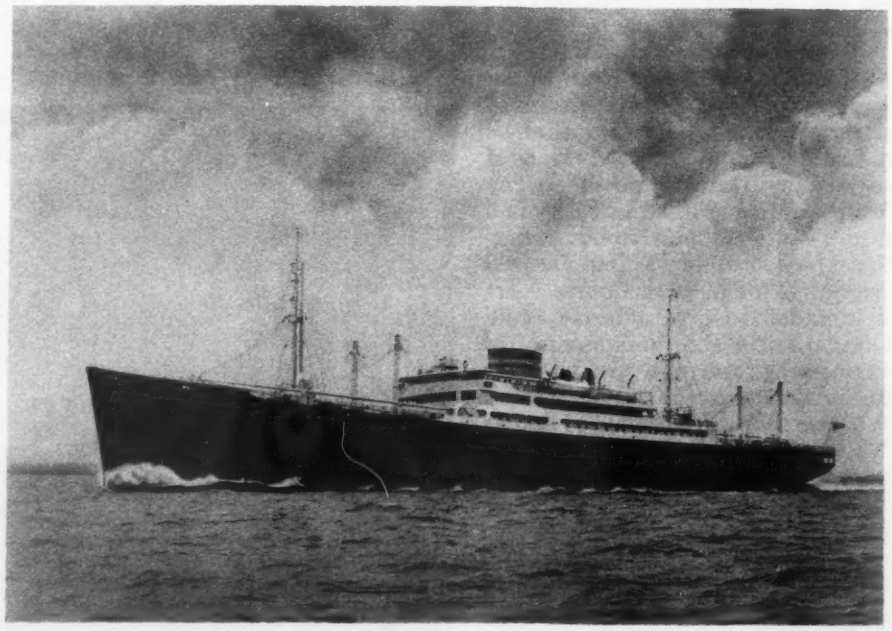
The U.S.S. "Wakefield" (nee U.S.S. "Manhattan") performed valuable service as a troop transport during the war

architecture and marine engineering. For this reason the shipbuilding industry has almost always been able to absorb the men trained in any of these schools who desire to work in this field. From 1934 until we entered the war approximately ninety per cent of the graduates of Course XIII entered the shipbuilding industry. Because of the broad basic engineering training provided in this course, graduates have also gone into industries other than shipbuilding. Some graduates have engaged in the design and construction of yachts.

Courses XIII-A and XIII-B, Naval Construction and Engineering

A special course for educating naval constructors for the United States Navy was set up in the Department of Naval Architecture and Marine Engineering in 1901 with Capt. William Hovgaard as Professor in charge of the course. Course XIII-A was maintained without substantial changes in the subject matter covered until 1939, when it was changed to a combined course in Naval Construction and Engineering. In addition to officers of the United States Navy, this course has been given to officers of the United States Coast Guard and the Department has trained naval constructors for the navies of Argentina, Brazil, Chile, China, Colombia, France, Mexico, Peru, Spain, Turkey, Uruguay, and Venezuela. There have been several large groups of foreign naval officers in the Department at the same time. All of the United States naval officers who are ship design and construction specialists now on the active list of the United States Navy received their postgraduate technical education at M. I. T.

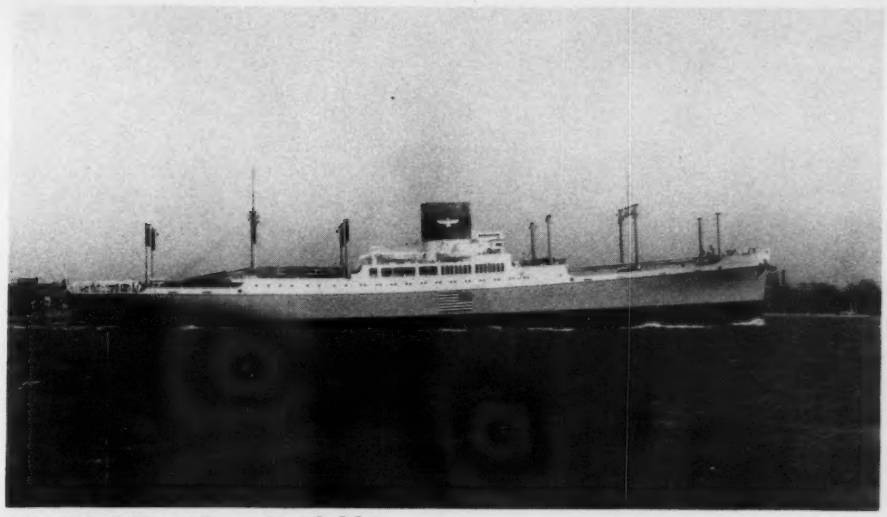
Course XIII-A deals with the fundamental technical features of the design and construction of military ships and their propelling machinery and the military considerations which distinguish such ships from commercial tonnage. The course has always been under the direction of a faculty member who had a background of experience as a naval constructor.



Bethlehem Steel Co.

The S.S. "Delbrasil," passenger vessel for South American service

During the first World War the course was suspended for two years. During the second World war, the course was continued but the instruction was speeded up to conform to the regular M. I. T. program at that time. Summer work, normally a part of this course, includes duty in navy yards and visits to the various naval research activities such as the Taylor Model Basin,



The S.S. "President Garfield"

Newport News Shipbuilding and Dry Dock Co.

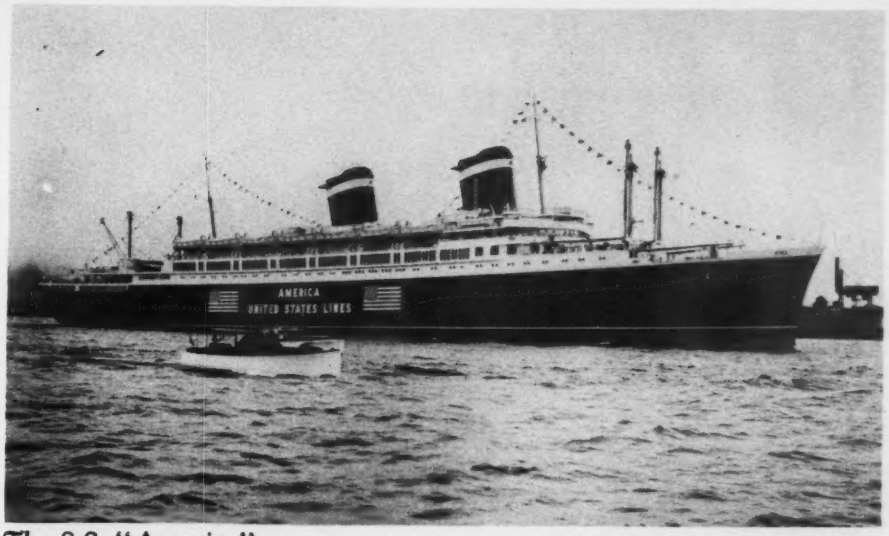
Naval Experimental Station and Naval Boiler and Turbine Laboratory.

Officers who complete this course are designated for engineering duty only, that is, they cease to be operating officers of the Navy and become engineering specialists. They are essentially in the status of staff officers and spend the greater part of their active careers ashore in the design, construction, and maintenance of the ships of the United States Navy and the inspection of equipment, materials and workmanship that enter into them. The Officers selected for this duty have in the past generally been honor graduates of the United States Naval Academy, but recently this course has been opened to naval reserve officers who have announced their intention of remaining in the naval service.

Course XIII-C, Marine Transportation:

A third course of study given in the Department of Naval Architecture and Marine Engineering is the Course in Marine Transportation (XIII-C). This Course was established in 1925 and the first regular class was graduated in 1931. Its purpose is to train men for positions on the shore staff of steamship companies and in allied pursuits. A study of the curri ulum will show that it gives the students a broad training in engineering, naval architecture, economics, and business administration studies, as well as in special subjects in the field of marine transportation, such as port facilities, cargo handling, ocean shipping administration and the economic and technical aspects of ship operation.

The Institute's Course in Marine Transportation is a unique one in that as far as we know it is the only one of its kind in the world. The need for a sound technical training for men who are to engage in shipbuilding and marine engineering has long been recognized. A course of training in the economic and engineering aspects of ship operation is a natural step and is now beginning to be recognized as essential. The keen competition in the shipping industry demands that serious attention be given to the technical and economic problems of ship operation and the rapid turn-around of ships in port. It also demands trained men in the various departments of a steamship company working up to the positions of responsibility.

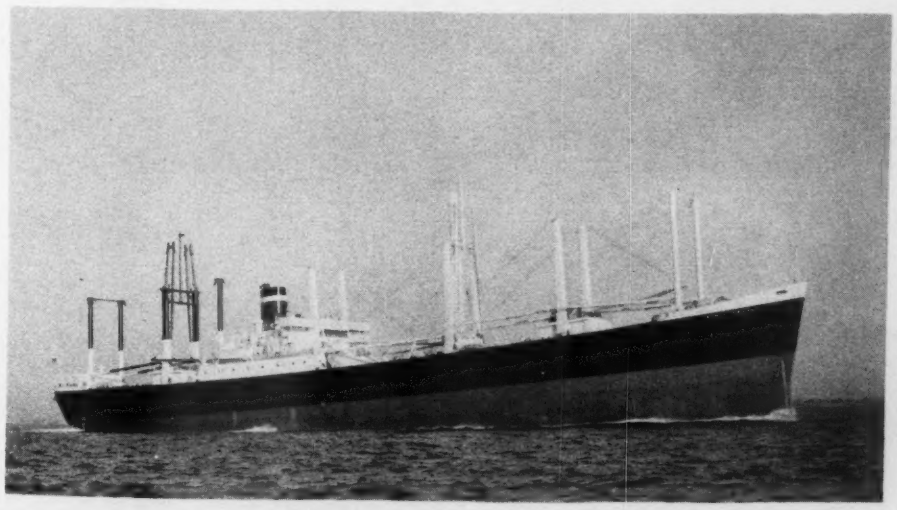


The S.S. "America"

Newport News Shipbuilding and Dry Dock Co.

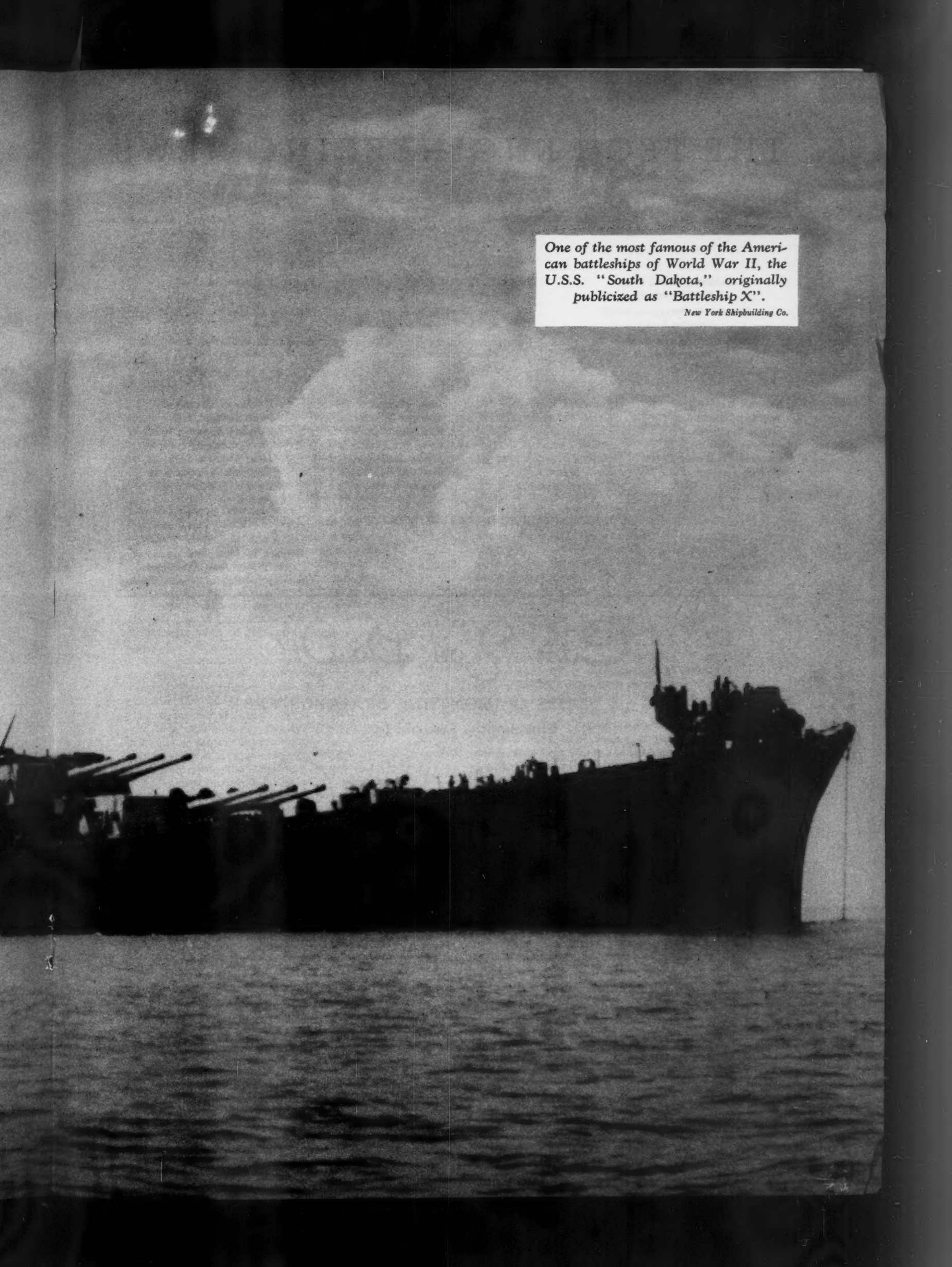
The S.S. "Santa Teresa," cargo vessel for the Grace Line, Inc.

Newport News Shipbuilding and Dry Dock Co.



An outstanding feature of the Course is that with the coöperation of various United States steamship companies the students spend their fourth year at sea on merchant ships. This gives them an opportunity to acquire some first-hand practical knowledge about the operation of ships and their power plants, the handling and stowage of ships' cargoes, world ports, and world trade before finishing their work at the Institute. The students return

(*Continued on page 322*)



One of the most famous of the American battleships of World War II, the U.S.S. "South Dakota," originally publicized as "Battleship X".

New York Shipbuilding Co.

THE TECH ENGINEERING NEWS

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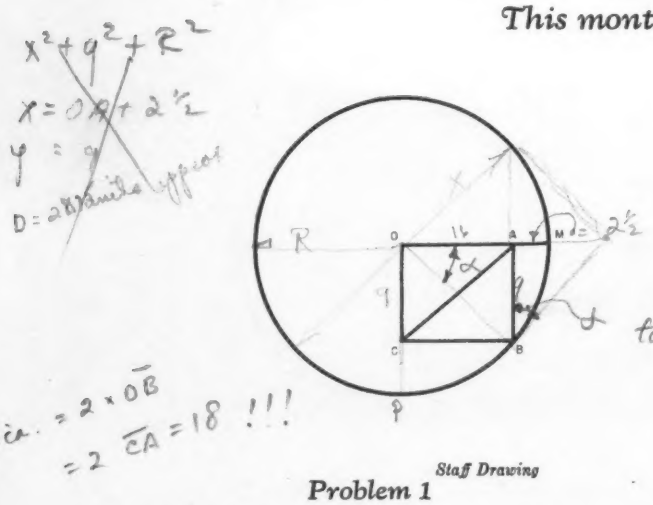
Can You Do It?

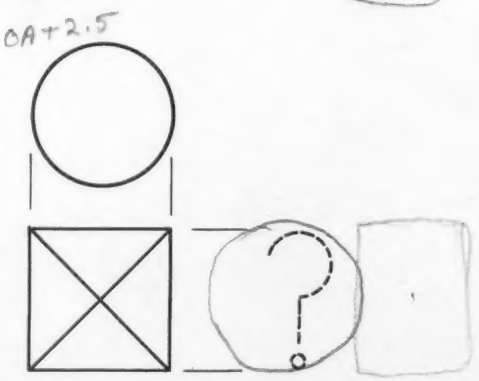
A SERIES OF MONTHLY BRAINBUSTERS

This month: Two old favorites . . .



Staff Drawing

Problem 1



Staff Drawing

Problem 2

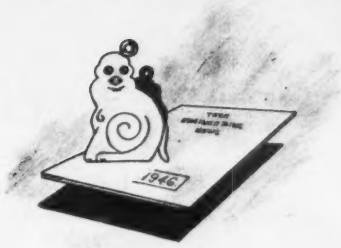
Problem 1: Here is one of the most famous of the simple geometry puzzlers. Given the circle, center at *O*, with radius *OM* drawn. From a point two and one-half units in from the circumference on this radius a perpendicular *AB* is dropped, *B* lying on the circle's circumference. The rectangle *ABCO* is completed, and line *CA* is drawn and found to be nine units long.

Thus: Given *AM* equal to two and one-half units and *CA* equal to nine units,
Find the diameter of the circle.

Problem 2: Here is one for the imagination. Given the two views of the object as drawn, find the third view.

(*Answers next month. Answer to last month's problem is on page 324*)

The Dragon's Den



An Offer . . .

It seems to us that a lot of these "famous" professional societies are existing in a state of levitation; they have no visible means of support. Worse, they never seem to do anything.

Tech is probably as well saturated with the myriad varieties of professional societies as any other institution, but like so many other activities around here, the societies seem to exist in name only. Some of the honorary organizations which do not pretend to offer educational or vocational guidance perform their appointed tasks with creditable efficiency, but even they suffer from a great lack of publicity. Once in a while an announcement appears, telling us the names of new pledges and members. The functionings of the main body of the society are, however, somewhat obscure.

The greatest offenders, in the long run, are the various "true" professional organizations or institutes such as the A. S. M. E., or the A. I. Ch. E. Almost all of these descend upon the unsuspecting freshman of their particular branch of study and inveigle him into paying the required membership fee. Then the mystery begins in earnest. With only a few exceptions, the freshman never hears from his new brotherhood for many months. Once in a while, national organs are sent him. This last is all for the good, but it still does not replace the local chapter of the society and undo its obligation to provide interesting plant visits or lectures — or even social affairs.

Recently there has been a movement in the general direction of activity on the part of some few of the societies around here. The A. I. E. E. ran a couple of plant trips and a visit to the differential analyzer. It is a good start, but let us keep it up. This is also true of several other groups that have suddenly begun to put up a good showing. The start is fine, but do not let it stop now.

There still are a few organizations, for example the A. I. Ch. E., which have utterly failed to do what is generally expected of them. It should be about time that the student body realizes such societies are mere deadwood, and that a true professional institute should mean more than a constitution and a monthly publication put out from national headquarters. The challenge is particularly applicable at this time since several groups, temporarily defunct during the war, are in the throes of reorganization.

While many of the individual groups may exhibit flaws and imperfections, the epitome of obscurity is the baby monster created by the professional societies as a body, the C. P. S. or Combined Professional Societies. With but few exceptions in the last year or so, the C. P. S. has been mentally extinct — if not physically. Somehow it still seems to elect officers and continue its nominal existance, but to the general view of the student, these gestures are without meaning or significance. It is results that count, and no results are forthcoming.

In days gone by it used to be the policy of *T. E. N.* to reserve at least a full page for the "Bulletin Board" as it was called. This page was to be used by the C. P. S. or any of its member organizations as an outlet for formal announcements or résumés of past or future events. But the "Bulletin Board" died a death of starvation. The societies never troubled themselves to furnish material nor were they aware of the publicity value of making full use of such material and space. After several issues within the last two volumes, the "Bulletin Board" was eliminated. True enough, material would occasionally be submitted — after much exertion on the part of the General Manager — but it was all of the cut-and-dried type, without life and badly timed. We feel that it is about time that something be done to remedy the situation, not only *about* space in *T. E. N.* but rather about the professional society situation as a whole.

Here is what we are offering as our contribution towards the goal. We will provide free space of any size within reason to the C. P. S. or any specific professional or honorary society, to be used as it sees fit.

We are not material-hungry and do not need such writing as "filler." We do feel, however, that it is our duty as the student undergraduate engineering publication to present interesting and alive reports of the activities of the local professional societies, and to help wherever possible in furthering the success and growth of any such organizations.

J. W. W.

The Pillory

Know all ye readers that the following persons have been convicted of being on the staff of that magazine known as The Tech Engineering News, and for that rank offense they are hereby sentenced to a one month stand in the public pillory.

John A. Contegni, 2-47

Down in the *T. E. N.* office there is a sign which perpetually hangs on the bulletin board in the "work to be done" section. It reads as follows: "Make or help the Business Manager clean his desk." Yes, you guessed it, the Business Manager is John Contegni, and his desk remains a mess.

When they ran him out of Jamaica, Long Island, John decided that Boston was the place for him (an Irish boy) and so ended up at this institution where he now claims to be a Junior. After three terms of continuous brownbagging John finally decided that life was hopeless anyway and so went out and joined *T. E. N.* John signed up for the literary staff, but before he had an opportunity to mar the literary reputation of the publication, he was whisked into the job of Circulation Manager. This was a job requiring much brown and little else — it suited John perfectly. We must give the young man credit, however, for bringing efficiency into the bundle-tying department and for cleaning up the corruption in the envelope sorting squad.

As Circulation Manager, John had an opportunity to display his business acumen, and so, when the new managing board was chosen last January, the powers of *T. E. N.* decided that John might make a good Business Manager or at least *a* Business Manager. And so it is that we now find Johnny down at the office "buggering the books" — with a textbook in accounting spread out in front of him.

Johnathan has by no means confined his endeavors to *T. E. N.*, but has stuck his nose into a myriad of other activities around the Institute. For instance, if you are lucky, you might catch him on a rainy Thurs-

(*Continued on page 320*)

Frank J. Heger, Jr., 2-47

To this day the halls of fair Manhasset High reverberate with the cheers, screeches, and screams of the Manhasset populace for their conquering hero, "little" Frankie. At the mellow age of sixteen years he packed his brief case, saddled his tricycle, and set out to discover if that which he had heard was really true — was Hell really situated in the quaint, aromic city of Cambridge, Massachusetts?

Propped high on his little three-wheeler, he crossed the aquamarine waters of the Long Island Sound (by ferry of course!). Reaching Providence, he was found wandering bewilderedly through the streets by several motherly Pembroke girls (ruff! ruff!). For several weeks they watched over him, and, undoubtedly, "little" Frankie would have been their cute little waif permanently had they not decided to ask him what he was

looking for in life. Yes, we can see him now as he raises his lustrous eyes, twitches his petite nose, and says with all the manliness in him — "I'm looking for Hell!"

And so it came to pass that our wandering hero was boarded up in a crate and shipped to the "Glorious Institute." Overflowing with innocence and unknowingness F. J. knocked at the door of some mysterious lab. The door was slowly opened, and a hand reached out and dragged him in. Without a moment's hesitation he was shoved through the Differential Analyzer, and thus the "facts and figures" of life were impressed upon his great numerical mind. After this episode he was affectionately tagged "Schlitz" by all those who knew him because here certainly was a boy with a head!

"Schlitz" gets a big thrill out of his position as

(*Continued on page 320*)

AWARD FOR SERVICE

A sleeping village in the path of a raging flood . . . at her switchboard an operator makes call after call to alert the community and summon aid. She leaves only when rising waters reach the board and the building itself becomes flooded.

For this and similar acts of public service, more than 1,200 telephone men and women have received the Bell System's most coveted award—the Theodore N. Vail Medal.

Service to the public has long been a tradition in the Bell System. The thought "service first"—day by day as well as in emergencies—has helped give this nation the best communications service in the world.

BELL TELEPHONE SYSTEM

BEARINGS

(*Continued from page 298*)

are run under the constant load F_1 and another group under the load F_2, but otherwise under identical operating conditions, the lives L_1 and L_2 respectively are obtained for the two groups. The following relation exists between load and life:

$$\frac{F_1}{F_2} = \sqrt[3]{\frac{L_2}{L_1}} \text{ or,}$$

$$F_1 \sqrt[3]{L_1} = F_2 \sqrt[3]{L_2} = \text{constant.}$$

This shows that the lighter the load the longer the life of the bearing. It can also be shown that:

$$L_n = \left(\frac{C}{P}\right)^3$$

which is ordinarily called the life formula.

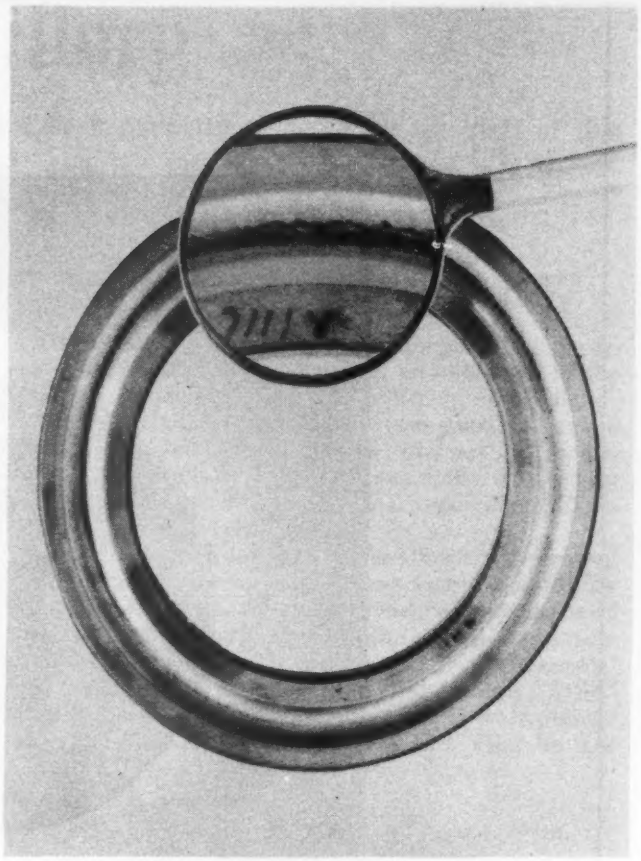
Here C is the specific capacity of the bearing; that is, the load-carrying capacity in kg. for a life of one million revolutions.

P is the equivalent bearing load in kg., and

L_n is the life in millions of revolutions under the bearing load P kg.

In this formula for the life of a bearing, P, the bearing load, is assumed to be constant and a pure radial force. If it varies in any way from this ideal case, the "equivalent load" must be used in calculations. The equivalent load is an imaginary load which has the same effect on a bearing as the actual load.

The Timken Roller Bearing Company has tested over 400,000,000 bearings and has found that their life expectancy is 3,000 hours with not more than 10 per cent failures. The average life is actually four or five times this figure. Timken rates its bearings at a speed of 500 rpm. and this rating is equal to the (calculated load) $\times$(the life factor)$\times$(an application factor). The life factor is obtained from the expected life of the bearing which is usually the life of the equipment in which the bearing is mounted. This life factor is calculated for fully loaded bearings. The application factor depends on variations in operating conditions such as shock, continuous duty, and inequality of loading.



Spiral shaped smearing streaks are caused by balls sliding in a direction diagonal to the direction of the rolling SKF Industries, Inc.

The specific capacity of a bearing is dependent upon the properties of the material, the dimensions of the rolling elements, the number of rolling elements, and the degree of osculation. (The degree of osculation depends on the length of the radii of curvature and the direction of motion of the rolling elements.) It has been found that small balls have a higher load carrying capacity than large balls. Experiment has shown that the load-carrying capacity varies with the ball diameter (D_w) approximately as $\frac{D_w^2}{1+.02\,D_w}$. According to Hertz' theory the load capacity should be proportional to D_w^2, but $\frac{1}{1+.02\,D_w}$ is a correction factor for the difference in capacity between large and small balls. The force of the rolling elements against the raceway varies with $\frac{1}{\cos\,\alpha}$, so that the load capacity is also proportional to $\cos\,\alpha$. If the bearing has (i) rows of rolling elements, the capacity is (i) times higher than that of a single row bearing. Summing up all the factors, the specific capacity of a ball

(*Continued on page 314*)

Heat treating bearing parts New Departure

Transportation pioneer

The two dominating spheres of achievement of George Westinghouse were *transportation* and *alternating current.*

His first major contribution to transportation was the famous Westinghouse air brake—followed, a few years later, by his development of automatic block-signaling systems for railroads.

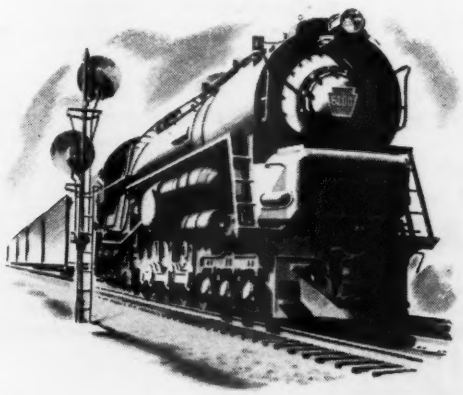
Later, this great inventor-engineer pioneered a single-reduction-gear direct current motor which caused sweeping changes in the operation of street railways.

But a unique achievement in the life of George Westinghouse came in 1905 — when he brought *transportation* and *alternating current* together in a single, masterful triumph of engineering.

For, on May 16, 1905, he successfully demonstrated the first *single-phase main-line* electric locomotive before the delegates to the International Railway Congress, at his plant in East Pittsburgh, Pa.

Shortly afterwards, in 1907, Westinghouse electrified the *first main-line railroad*... the New York, New Haven & Hartford, between Woodlawn, New York, and Stamford, Conn.

This spectacular accomplishment heralded the major electrification of railroads the world over.



Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY *... A* new and revolutionary *type of locomotive is hauling heavy trains over the Pennsylvania Railroad Lines. It is powered by a Westinghouse* geared steam turbine *... the smoothest, most compact, most efficient source of steam power ever devised by man. In addition to many products used by railroads, the Westinghouse Electric Corporation also builds electric mine locomotives and other types for industrial use.*

Tune in: JOHN CHARLES THOMAS—*Sunday, 2:30 pm, EST, NBC* • TED MALONE—*Monday through Friday, 11:45 am, EST, American Network*

Straight talk about your after-college job

No. 4. An Engineer's Job Should Be Exciting To Him

WHEN A MAN finds his work exciting, he will be stimulated to do his *best* work.

That is a point we think every young engineer would do well to consider before he applies for a job anywhere.

If you like variety and enjoy meeting a perpetual challenge of doing the job better, you will find much to attract you to the Timken Roller Bearing Company.

For no other product is involved in the basic design of so many other products in so many industries as Timken Roller Bearings.

■ As an engineer for the bearing division of this company, you might one day be working on problems which would take you 25,000 feet in the air. And the next week, you might work 5,000 feet underground. In rapid succession, your job might shift from bearings for a machine tool, to bearings for an automobile, a farm tractor, a drilling rig, a locomotive or any product which has revolving wheels, or shafts.

You would have to know basic working conditions for many products. You would have to keep pace with technological advances. And because bearings are an important part of design, you would in many cases, be asked to help work out the design of a wide variety of new products. With this company, your work will be as varied and absorbing as the whole of America's dynamic industry.

As training for this work, we operate a practical "Work-as-You-Learn" Plan for young graduate engineers who measure up to our standards. There are no classes. While doing productive work in the various departments of our factory, each man is carefully watched and supervised by experienced and highly skilled engineers with a view to developing special aptitudes.

■ When a man, in our opinion, becomes sufficiently grounded in the basic principles of our business, he is assigned to the line of work for which he is best fitted.

Many executives now in responsible positions with our company, started in this way.

Again, this year we want to hire a limited number of men from leading engineering schools; men who we hope will make a successful career for themselves with us. If you will soon have a Bachelor of Science Degree in Engineering, we would like to talk with you now. Write The Timken Roller Bearing Company, Canton 6, Ohio.

The Timken "Work-as-You-Learn" Plan of Training

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9. Sales Order Department
10. Sales Engineering in Field

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2. Steel Rolling Mills
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4. Bar Finishing and Inspection
5. Tube Finishing, Heat Treating and Inspection
6. Stainless Steel Forge Shop
7. Tool Steel Mill and Forge Shop
8. Production Scheduling Department
9. Metallurgical Laboratory
10. Metallurgical Service (Customer Contacts)

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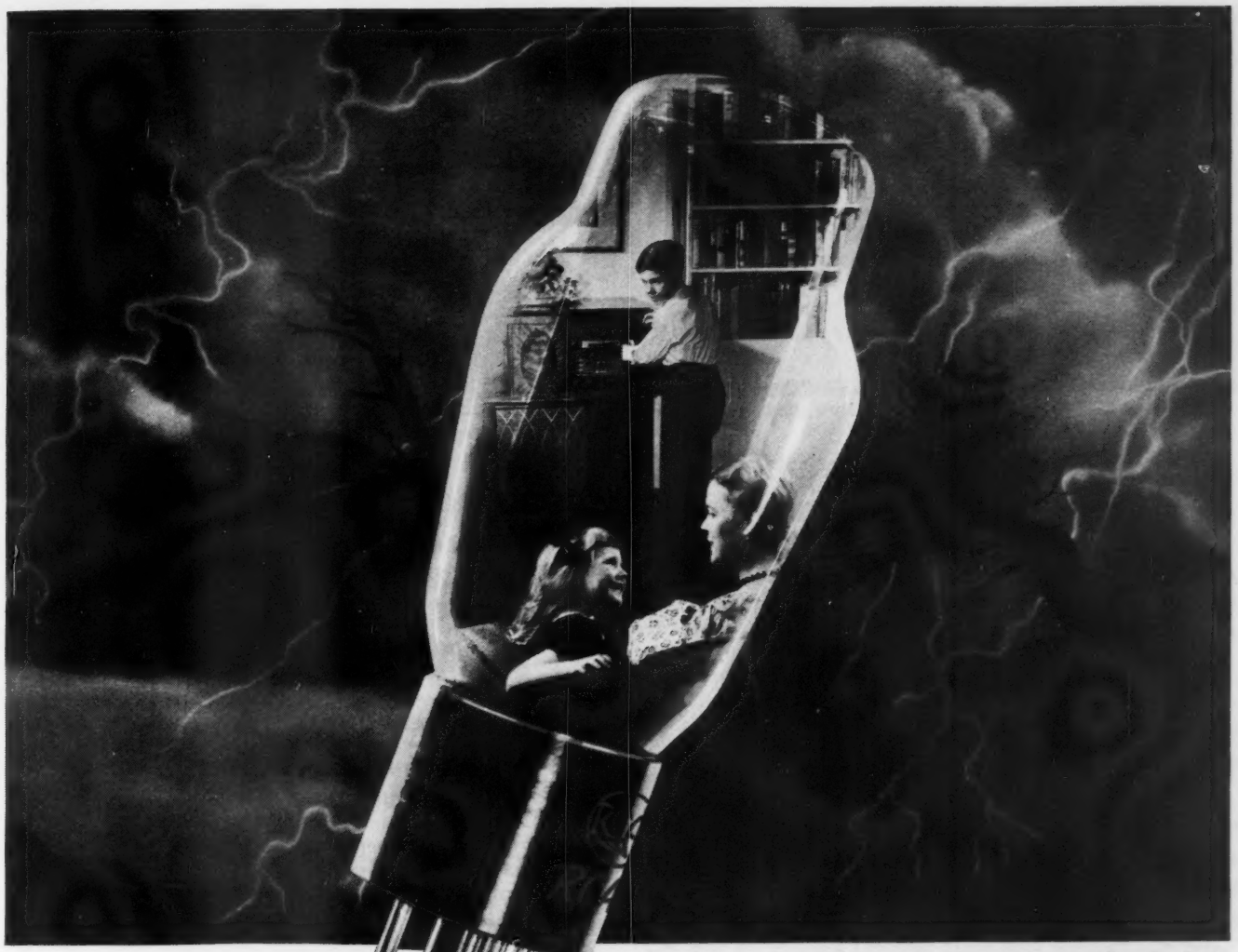


FM radio receivers are more static-free and less costly—thanks to research at RCA Laboratories.

NEW FM - noiseless as the inside of a vacuum tube!

Now, FM, or Frequency Modulation reception, provides still greater freedom from static and interference caused by storms, ignition systems, oil burners, and domestic appliances.

It's radio at its finest—making your living room a part of the concert hall itself. You've no idea of how marvelous music can sound over the radio until you hear the golden perfection of FM reception developed by RCA.

Moreover, through this new RCA development, FM receivers can be made at a cost comparable to that of standard-band broadcast receivers. FM is no longer expensive! "Better things at lower cost" is one of the purposes of RCA Laboratories – where similar research is constantly going into *all* RCA products.

And when you buy anything bearing the RCA Victor name – from a television receiver to a radio tube replacement—you know you are getting one of the finest instruments of its kind that science has yet achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20. Listen to The RCA Victor Show, Sundays, 4:30 P.M., Eastern Standard Time, over the NBC Network.

Stuart William Seeley, Manager of the Industry Service Laboratory, RCA Laboratories Division, perfected this new FM circuit. It not only operates equally effectively with strong or weak stations, but lowers the cost of receivers by eliminating additional tubes and parts that were formerly considered necessary in Frequency Modulation receivers.

RCA **RADIO CORPORATION of AMERICA**

BEARINGS

(*Continued from page 310*)

bearing is

$$C=f_c\frac{iD_w^2z^{2/3}\cos\alpha}{1+.02\ D_w}$$

and that of a roller bearing is

$$C=f_c iD_w l_w z^{2/3}\cos\alpha$$

where z is the number of rolling elements per row
l_w is the length of roller contact
D_w is the roller diameter and
f_c is the coefficient depending on the material and degree of osculation.

Due to research developments and improved manufacturing methods, bearing capacity has been increased from time to time.

The bearing in a machine must transmit forces between machine parts which rotate in relation to each other. In determining the design, material, and size of the bearing, the magnitude and direction of the forces which will act on the bearing must be considered. Selection of life factor and safety factor are based on the stresses to which the bearing will be subjected. The selection of bearing type is made with regard to load, speed, fits and mounting, and maintenance. Since these many factors must be considered before a bearing is used for a particular job, the mechanics of ball and roller bearings is important. There are hundreds of formulas used to calculate capacities, life factors, equivalent loads, and forces in bearings, and these formulas are practical because they are used in bearing selection.

Another important division of bearing mechanics is lubrication. To prevent dust particles from getting into bearings, the manufacturers have designed many sealing devices. Grease is employed to add to the efficiency of the seal and repel water. If oil lubrication is necessary, the bearing seal must prevent leakage of this oil. Due to difficulties in obtaining excellent seals, oil lubrication is used only when necessary, for instance, if the speed of rotation is high, resulting in such high temperatures that grease cannot be used. Felt rings and labyrinth seals are used to give bearings good protection against dust and dirt. When oil is used for lubrication, there must be enough oil to form a protective film on the roller and raceways, yet too much oil causes friction. Mist or atomized lubrication is often used for high speed bearings. The lubricant consists of a mixture of minute oil particles and air, transmitted under pressure into the bearing housing.

Due to the friction in bearings heat is developed, thus increasing the temperature of the bearing. Part of the heat is given off from the bearing surface by radiation and convection. The radiation from a bearing housing can be calculated from:

$$\omega_1=10^{-4}e\varphi,\quad \text{watt/cm}^2$$

where e is a radiation coefficient, dependent upon the surface condition. It varies from zero to one, being lower for polished surfaces.
φ_1 is a radiation function dependent upon the sure face temperature T_1°C. and the temperature differential T_1-T_0°C. between the radiating surface and the surrounding air. It varies from four to ten when the temperatures are between −10°C. and +50°C.

The air around a bearing rises as a result of being heated; therefore, a current of air develops that touches the surfaces and convection results. The heat transfer due to convection is given by:

$$\omega_2=\varphi_2\sqrt[4]{\frac{v^3}{l}}$$

where φ_2 is a radiation function
V^3 is the velocity of air in the bearing and
l is the length of flow of air (if a tube, l is the diameter of the tube).

In estimating the bearing temperature the following factors must be known:

1. The friction torque and speed of rotation.
2. The rate of heat output.
3. The cooling area of the bearing housing.
4. The fan action of the rotating parts which change the velocity of the air.
5. The temperature of the surrounding air.

The rate of the development of heat energy (W_E) due to the bearing friction torque (M_E) at the speed of rotation (n) rpm, is given by:

$$W_F=nM_F\cdot10^{-3}$$

The cooling factor (W_S)watt/°C. is the power dissipated to the surrounding air per degree Centigrade of temperature differential. Due to the equilibrium between heat input and heat output when a steady state is reached,

$$W_F=W_S\,(T_m-T_0)$$

where T_m is the average bearing temperature, °C.
T_0 is the temperature of the surrounding air, °C.

Bearing housings are made with a sufficiently high surface area so that the heat developed can be carried away without the bearing temperature becoming too high. The power loss which escapes as heat can be reduced to a minimum by using good lubricant and lubrication methods. Water jackets, fans, and cooling disks are used to keep the bearing temperature at a minimum. Cooling disks increase the air currents and surface area so that heat is dissipated rapidly.

The mechanics of ball and roller bearings is important to the manufacturer and although many of the quantitative measurements are only theoretical, they have been useful in determining what can be expected from bearings and what type of improvements should be made in order to reduce the friction menace to a minimum. It is evident that industry deems engineering and mechanical research on bearings an important expense, because SKF Industries and others maintain laboratories abroad as well as in the United States.

Thanks to Dr. Arvid Palmgren of SKF Industries for the theoretical information contained in this article.

Next Month

in T. E. N.:

— Finite Geometry

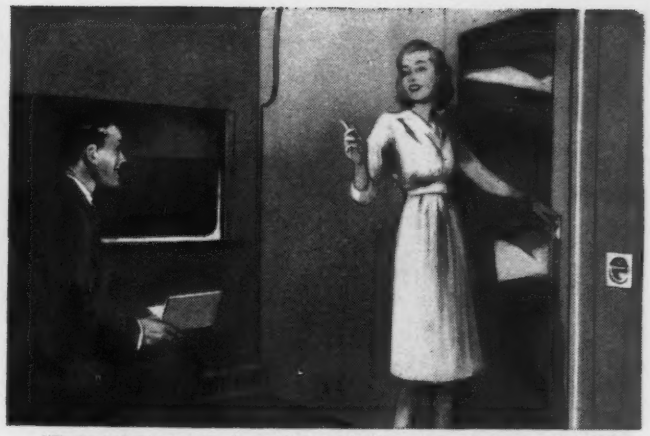
— The Turbo-Encabulator

— Spiral Nebulae

and others

BE SURE TO GET YOUR COPY

"Traveling is fun when we can all be together like this."



"They're both asleep. And so happy. This is wonderful—to have a Master Room like this."

Suppose you want to take the children

You reserve two Double Bedrooms in the new Budd-designed sleeping car. The porter folds back the partition between them to make one large, spacious Master Room for the day. You have two wide, panorama windows with unobstructed view. There are six comfortable seats in case friends you meet on the train come in to visit. You may have a table for games or for dining en famille. There is plenty of room.

When bedtime comes, the partition is put in place and you have two rooms, with a communicating door. Each Double Bedroom has its own enclosed toilet room with lavatory and shower bath. The children can go to bed early and sleep undisturbed.

This new Double Bedroom, the first really satisfactory double bedroom ever designed, is only one of the new Budd developments for better trains, more comfortable travel, in the post-war world. You will see them soon on many railroads from the Atlantic to the Pacific. Budd builds trains of stainless steel, the strongest and safest material used in railway car structures.

EDWARD G. BUDD MANUFACTURING COMPANY
PHILADELPHIA • DETROIT

Budd

Originators of stainless steel lightweight trains, ALLSTEEL* *auto bodies and stainless steel highway truck trailers. Designers and makers of airplane and marine structures. Inventors of the* SHOTWELD* *system of fabricating hi-tensile steel.*

*REG. U. S. PAT. OFF.

ION EXCHANGE RESINS

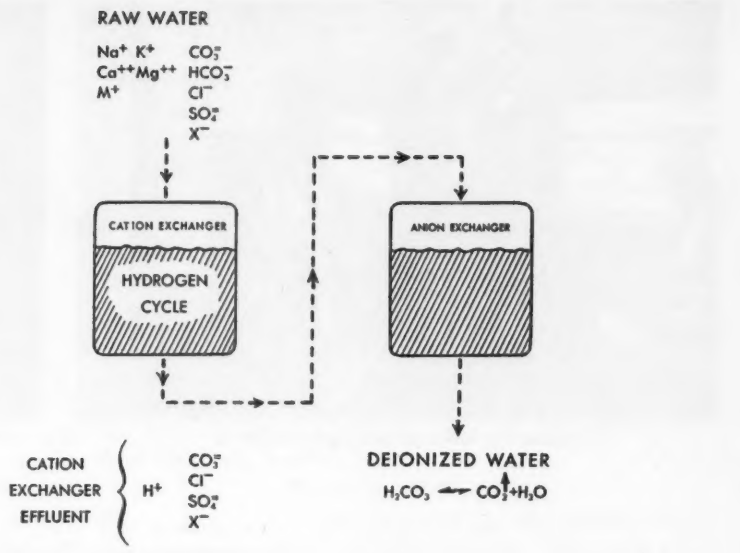
(*Continued from page 300*)

may occur due to strains imposed upon the exchanger bed by the constant interchange of ions of varying diameters.

2. Higher exchange rate, permitting higher loading and greater throughput. Variations in loading are readily assimilated, so that the effluent is uniform at all times. Greater throughput (higher permissible flow rates) permits the construction of beds of smaller diameter, with a consequent saving in floor space.

3. Higher capacity per unit weight or volume. This results in less frequent shut-down for regeneration, insures longer runs and a more continuous supply, with a reduction in labor costs. With the same schedule of regeneration, the higher capacity of synthetic resins permits the construction of smaller units, with the consequent saving in construction and material costs. In application where the floor space or head room is limited, this smaller sized unit is particularly advantageous.

4. Sharp "break-through" with no "leakage." This means a constant and high degree of purification until the bed is depleted. There is no gradual increase of solid content in the effluent as the exchanger approaches the practical exhaustion value.



Deionizing

The Resinous Products and Chemical Co.

5. Uniformity of quality, both physical and chemical, due to precise manufacturing methods and careful chemical control. Since the resinous exchangers are true synthetic resins, the preparative technique developed over a period of years has been adapted to their manufacture.

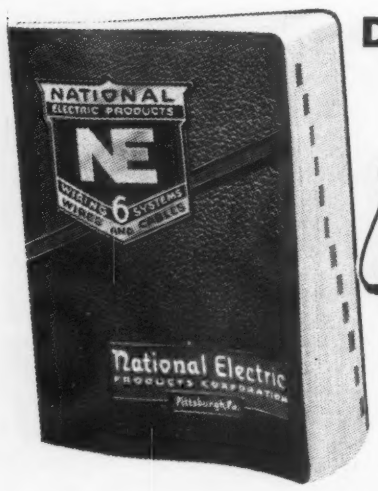
6. Lower density. This results in the use of a lower backwash rate, and consequently the use of a smaller quantity of backwash water. In areas of low pressure,

(*Continued on page 326*)

Our 350 Page

Electrical Engineering

Data Book



FREE!

This most comprehensive book on wires, cables, bus systems, conduits and surface raceways and their fittings is yours for the writing. Informative and instructive, you will find it very helpful in your work.

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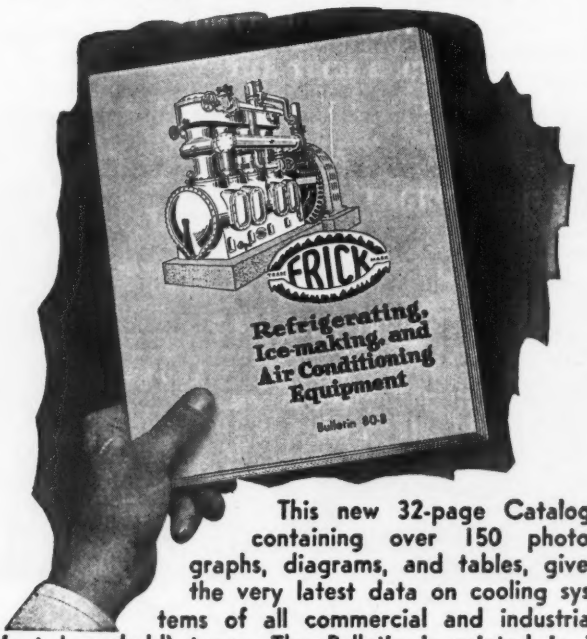
Get this informative book . . .



This new 32-page Catalog, containing over 150 photographs, diagrams, and tables, gives the very latest data on cooling systems of all commercial and industrial (not household) types. The Bulletin is printed in 3 colors, in full letter size, and has a durable cover. It is one of the most informative books ever published on refrigerating machinery.

If you or your friends need such equipment, ask for your copy of Bulletin 80-B, today. In writing, please describe carefully the cooling work to be done.

FRICK COMPANY, Waynesboro, Penna.

WHAT KIND OF POISON IS THIS?

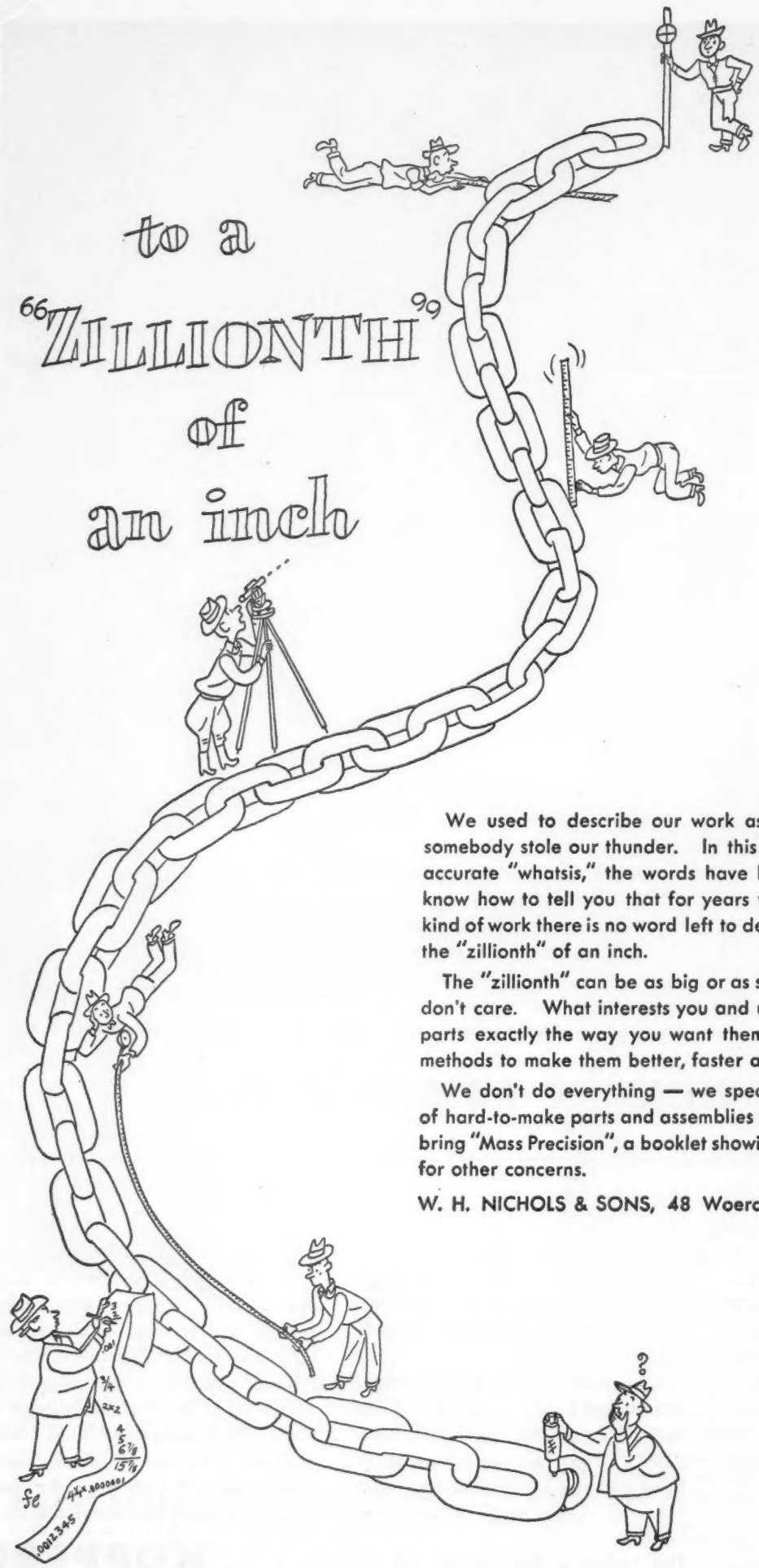
SOME POISONS ARE KILLERS. Others are preservatives. Creosote is one of the "others" . . . a protective agent which preserves timber against the attacks of decay, termites, and marine borers. Those destructive agents cause millions of dollars worth of damage every year . . . but when wood is pressure-treated with creosote, it becomes toxic to them.

Koppers pressure-treats about 50,000 carloads of lumber and other forest products every year. Its creosote treatments baffle decay, termites, and water worms. Other specialized treatments make wood resistant to acid and abrasion, as well as to decay and fire.

The result is that wooden structures of all kinds . . . bridges, farm buildings, railroad ties, telephone poles . . . all last more than three times as long as they used to. And this, in turn, helps to conserve America's invaluable forests.

Wood preserving is only one Koppers activity. Koppers also makes paving and roofing materials, designs and builds coke ovens, manufactures piston rings, couplings, chemicals from coal and engages in many other activities. That's why Koppers is known as "the industry that serves all industry." Koppers Company, Inc., Pittsburgh 19, Pa.

The industry that serves all industry . . . KOPPERS



We used to describe our work as "accurate" and "precise," but somebody stole our thunder. In this age of precision "whosis" and accurate "whatsis," the words have lost their meaning. We don't know how to tell you that for years we have done, and still do, the kind of work there is no word left to describe — so we invented one — the "zillionth" of an inch.

The "zillionth" can be as big or as small as you want it to be — we don't care. What interests you and us is that we not only will make parts exactly the way you want them, but we'll develop production methods to make them better, faster and cheaper.

We don't do everything — we specialize in a fine production job of hard-to-make parts and assemblies in metal. A note from you will bring "Mass Precision", a booklet showing products that we have made for other concerns.

W. H. NICHOLS & SONS, 48 Woerd Avenue, Waltham 54, Mass.

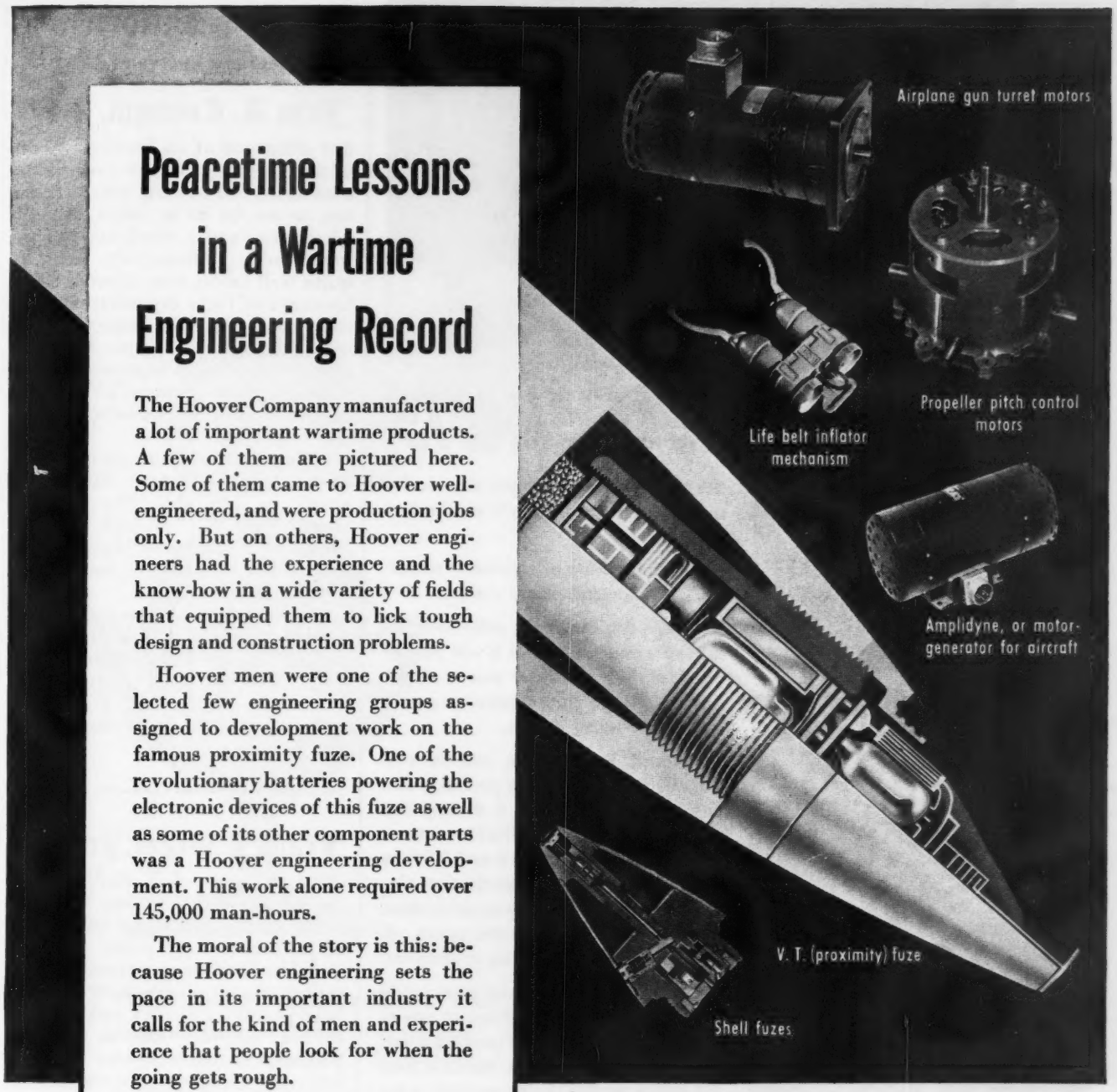
ni

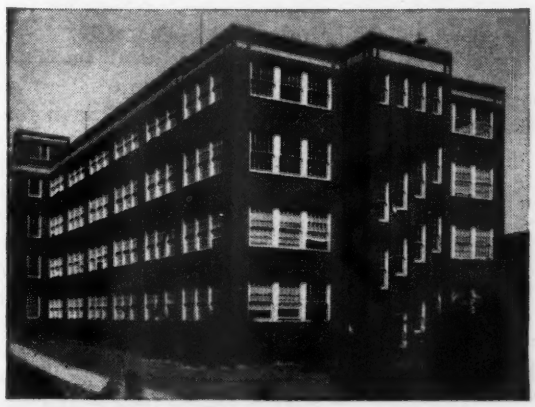
Peacetime Lessons in a Wartime Engineering Record

The Hoover Company manufactured a lot of important wartime products. A few of them are pictured here. Some of them came to Hoover well-engineered, and were production jobs only. But on others, Hoover engineers had the experience and the know-how in a wide variety of fields that equipped them to lick tough design and construction problems.

Hoover men were one of the selected few engineering groups assigned to development work on the famous proximity fuze. One of the revolutionary batteries powering the electronic devices of this fuze as well as some of its other component parts was a Hoover engineering development. This work alone required over 145,000 man-hours.

The moral of the story is this: because Hoover engineering sets the pace in its important industry it calls for the kind of men and experience that people look for when the going gets rough.





This modern four-story brick building, totaling 60,000 square feet of floor space and containing up-to-date laboratory equipment, is the Hoover Engineering Department.

The Hoover Cleaner is "born" in the development engineering division, where teamworking skilled designers, inventors and engineers plan tomorrow's electric cleaners.

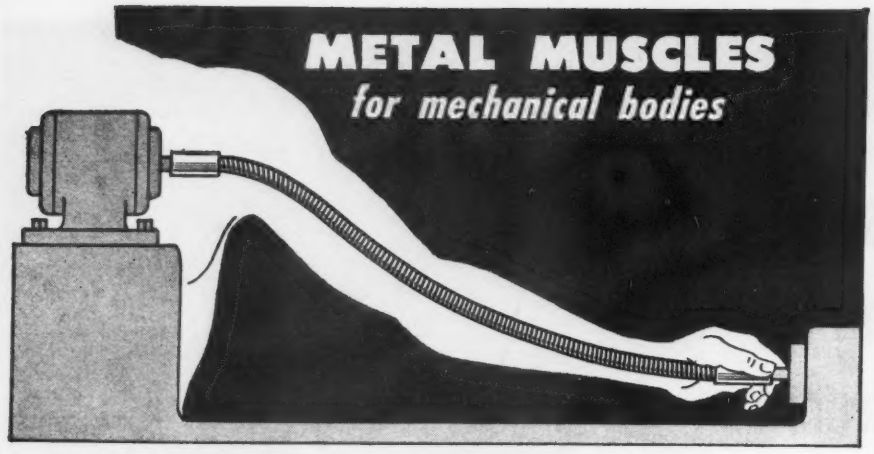
The laboratory division studies and tests, rejects or recommends each component part of each new product "to be."

Mechanical engineers measure noise and vibration, design fan systems, study cleaning methods and solve power transmission problems in developing new designs.

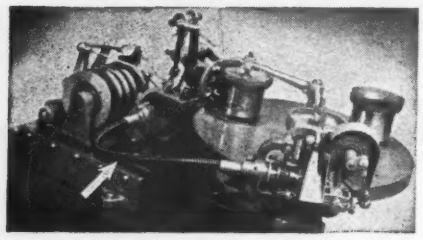
Electrical engineers develop and test motors, wiring, switches, lamps, etc., designing the right power plant and electrical accessories for a Hoover.

Product engineers solve manufacturing problems, set up standards, see that Hoover quality is maintained.

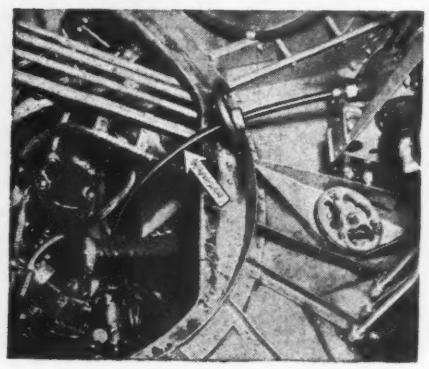
THE HOOVER COMPANY • *North Canton, Ohio*



S.S.WHITE FLEXIBLE SHAFTS



In this machine a flexible shaft (arrow) takes power from the main drive and carries it around a right angle turn to drive an auxiliary mechanism. Compare the simplicity of this arrangement with any other possible means of doing this job.



In this application on a large airliner, the flexible shaft takes power from the engine to drive the electric tachometer generator at the upper right. It typifies the ready adaptability of flexible shafts for all kinds of drives.

are metal muscles expressly created for performing two functions in mechanical bodies:

(1) Transmission of rotational power.
(2) Mechanical remote control.

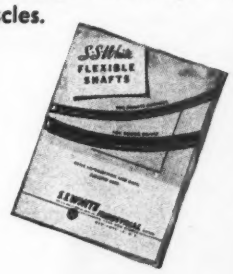
S.S.White flexible shafts offer such important advantages that it will pay to consider their use every time a power drive or remote control problem comes up in engineering design.

Suppose, for example, you have to transmit power from one part of a machine to another where a straight line drive is not practicable. The fewest parts with which it can be done is an S.S.White flexible shaft — a single mechanical element that will provide a positive drive between practically any two points, regardless of turns, obstacles or distance.

This basic simplicity, plus their ready adaptability to a wide range of power drive and remote control conditions and requirements, are main reasons why S.S.White flexible shafts are used to the extent of millions of feet annually — and why engineers will find it helpful to be familiar with the range and scope of these Metal Muscles.

WRITE FOR BULLETIN 4501

This bulletin will give you the basic information and technical data about flexible shafts and their uses. A copy is yours for the asking. Please mention your college and course when you write.



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FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
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The Pillory

(*Continued from page 308*)

John A. Contegni, 2-47

day afternoon at an Institute Committee meeting. If you ever desire a basketball or bowling pin, he is the one to see for he is Dorm Athletic Chairman (and a swell athlete, we might add). Financially, John is quite well taken care of since he is treasurer of three organizations, besides controlling the money of this mag. He even finds time occasionally to do a bit of homework or to drop over to the Course XVII drafting room for a few moments of rest and relaxation.

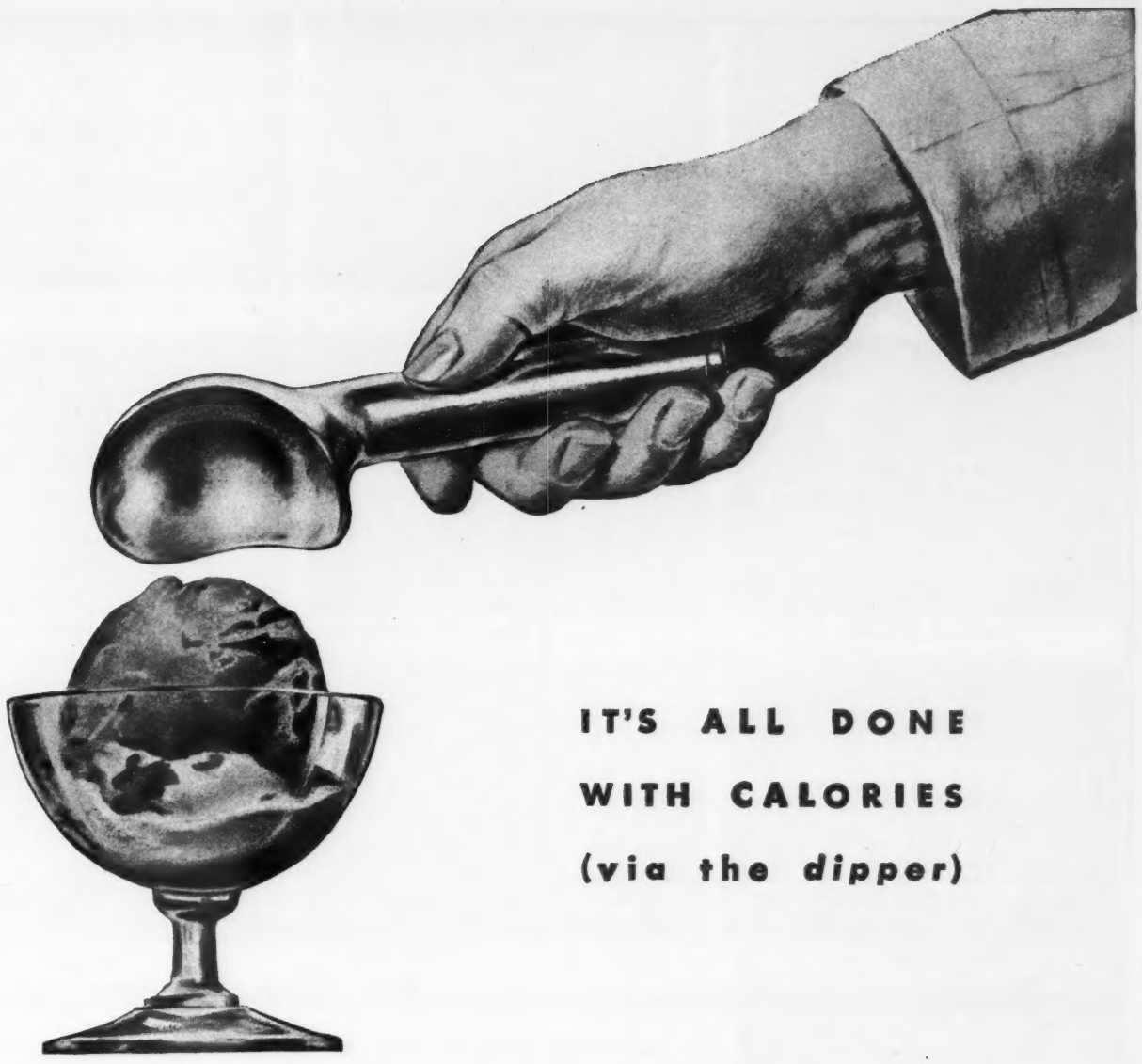
There is much more we could say about John, but very little of it would be printable. So we shall simply wish *T. E. N.* luck with the "hacker" as Business Manager and hope it has enough reserves to carry it through the crisis.

In case any of his various girl friends should read this article, we had better add that John is really a swell fellow and a very hard worker. We must admit that *T. E. N.* is indeed fortunate in having him on its Managing Board.

Frank J. Heger, Jr., 2-47

office manager of *T. E. N.* Before the advent of his regime the office was a raving madhouse with heaps of junk and dirty paper (*Voo Doo* and *The Tech*) strewn throughout to sop up the river caused by an overhead plumbing display and the tears of our weeping General Manager whenever monthly sales dropped from ten to nine — thousand, that is. Today complete order prevails. [*Ed. note:* What!] Even the Managing Board trembles when F. J. whips out his cat-o'-nine-tails and sends them scurrying for the brooms and paper baskets.

Occasionally F. J. is bitten by the lit bug and turns out an article or two. Really one can readily describe his style as unique. But "Schlitz" would go even further than that. He would describe it as the "quintessence of scrumptious literature." We won't argue about it here — we'll simply leave it to our faithful readers to decide. In any case, we are sure that you will agree that it is the quintessence of something — or other. Frank really tries his best to please, and in the final analysis we guess that he's a darn good egg.



IT'S ALL DONE WITH CALORIES (via the *dipper*)

There's been an endless parade of mechanisms to eject ice cream from dippers.

But somebody noodled... "Why not make a dipper with no moving parts?" Make it so that calories of heat from the user's hand shoot right down the handle to the cup. Then the ice cream will drop out easily.

That called for a material that transfers heat fast. So the dipper was made of Alcoa Aluminum, and the hollow handle filled with liquid. And, by golly, it worked . . . perfectly. The dipper sells.

No "Einstein" at work here . . . just plain American ingenuity of the kind graduated every year from our colleges and universities. Imagination plus engineering . . . or "Imagineering" as we like to call it at Alcoa . . . did the trick.

This is just one example of invention and adaptation of things *aluminum* . . . of men with ideas working them out in this versatile metal. Men who do this often draw upon the greatest fund of aluminum knowledge in the world . . . Alcoa's. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN **ALUMINUM**

DEAR VETERAN:

Do you want:

- More local housing?
- Better co-ordinated veterans' centers — less red tape?
- Full employment in a richer, more stable country?

To be sure of having these things, we must work together for them.

AVC has led the campaign for:

- The Wyatt housing program
- An efficient Veterans' Administration
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Cambridge AVC has:

- Helped co-ordinate local veterans' center
- Pressed for increased local and university housing programs
- Backed Massachusetts FEPC

JOIN AVC

(*The American Veterans' Committee*)

The vigorous, democratic organization for World War II veterans, members of Merchant Marine, American Field Service and accredited war correspondents

CAMBRIDGE CHAPTER

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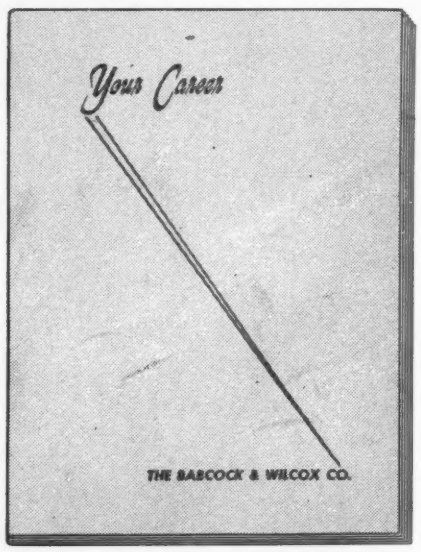
NAVAL ARCHITECTURE AND MARINE ENGINEERING

(*Continued from page 303*)

to the Institute with an excellent training for an appreciation of the studies taken during their fifth year.

While at sea the students serve as regular members of the ship's crew usually as student observers or cadets. Often a student sails on more than one ship during his twelve months away from the Institute. The ships on which the students sail naturally visit numerous ports of the world and this allows the men to study the layout and function of various world ports. A map located on the second floor corridor of Building 5 shows the ports which have been visited by the students during this year at sea.

Naturally the demand for men in marine transportation is not as large as in other engineering fields, and hence the number of men taking this Course is limited. Since 1931 about eighty men have been graduated from Course XIII-C and many of these have taken positions in various departments of American steamship companies. Some have entered other engineering fields and a few have gone into shipbuilding and in activities allied to marine transportaton, such as admiralty law and marine insurance.



Career Opportunities for Graduates

As a career-minded technical student, you will be interested in the story of The Babcock & Wilcox Company in terms of *your* future.

Best known for the manufacture of stationary and marine boilers, B&W is also a leading producer of many other types of equipment for steam and heat utilization. Due to the continuously increasing diversification of its activities, to continuing progress in product and process development, and to the size of Company operations, B&W offers expanding opportunities in many fields such as manufacturing, engineering, research, and sales.

We shall be glad to discuss these opportunities with you in the light of your training, aptitudes, and interests. First, however, we suggest you send for the booklet, "Your Career". Address your inquiry to The Babcock & Wilcox Company, Personnel Department, 85 Liberty Street, New York 6, N. Y. G-328

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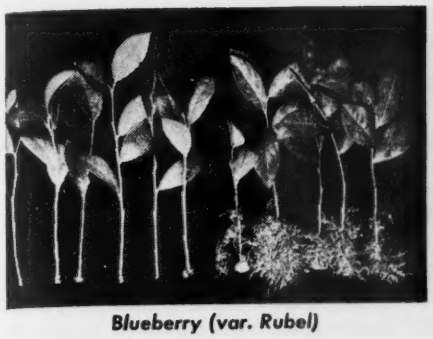
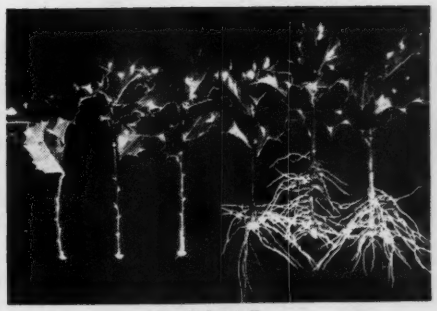
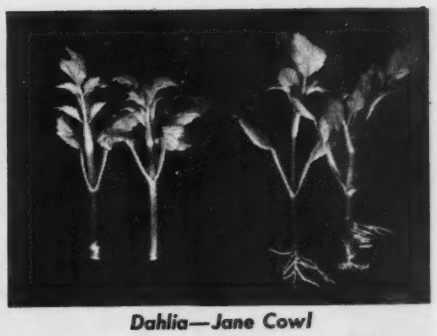


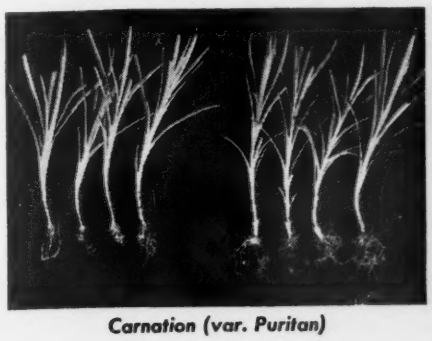
Blueberry (var. Rubel)



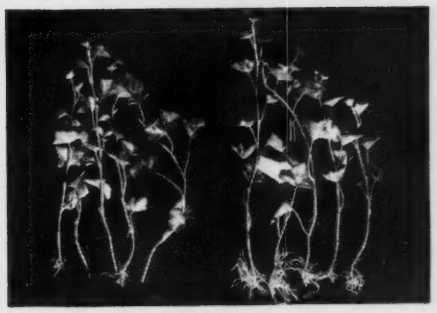
English Holly



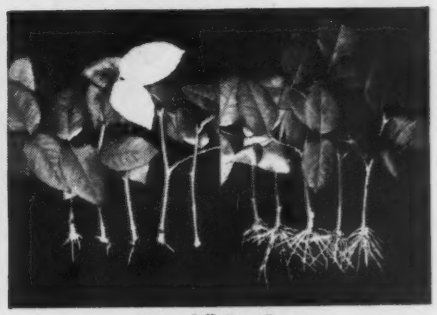
Dahlia—Jane Cowl



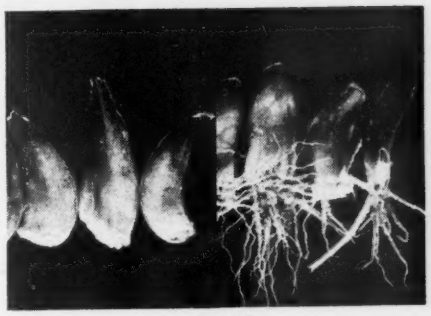
Carnation (var. Puritan)



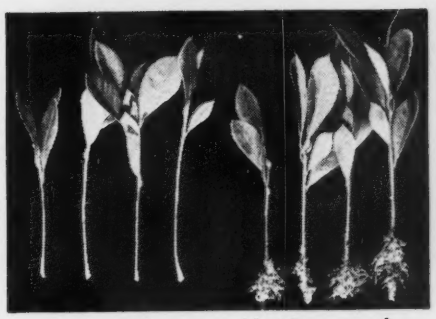
English Ivy



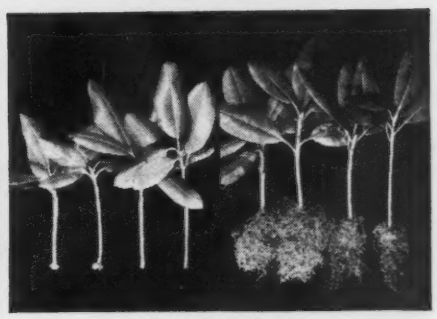
Briarcliff Tea Rose



Regal Lily



Azalea Arborescens (deciduous type)



Hybrid Rhododendron

There's always something doing in a chemical plant

Recently some of our specialists have been studying synthetic plant growth substances. One of the results of these investigations is Quick-Root, a new product of great interest to greenhouse operators and nurserymen. Treatment of cuttings and slips promotes rooting, resulting in more abundant and sturdier roots and healthier, more vigorous plants.

There's always something doing in the plants of a great chemical organization—interesting work in progress to develop new products or to find a formula or method that will improve materials already in wide use.

Hundreds of technicians are busy in our Dow plants with work of this nature. Some may be interested in agricultural chemistry, others in pharmaceutical chemicals, or plastics or the ultra-light metal, magnesium. The field is wide and varied—a constantly growing field for young men with an aptitude for science.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

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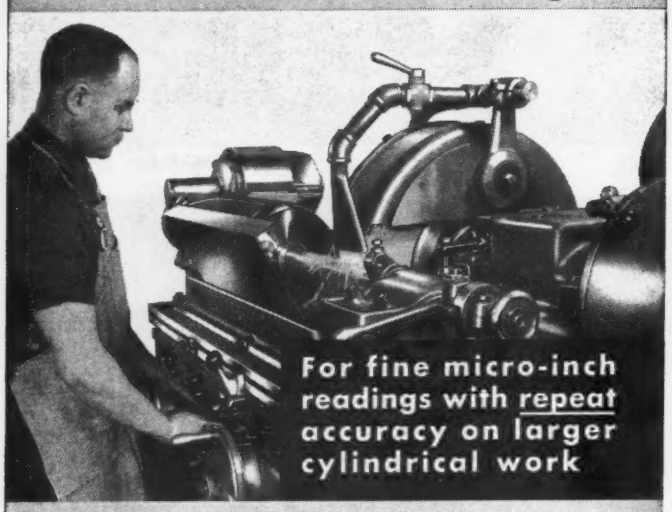
20 SERIES' EASE OF OPERATION
Saves Time in Grinding



Let us show you the production possibilities of these ***Electrically Controlled*** Plain Grinding Machines.

No. 20 (10"x 18")
No. 22 (10"x 36")
No. 23 (10"x 48")

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BROWN & SHARPE

WHY AND WHEN TO USE

BULLETIN OK-1013 tells where and how to install Okonite Varnished Cambric Insulated Wires and Cables. Secure it by writing to The Okonite Company, Passaic, New Jersey.

OKONITE
INSULATED WIRES AND CABLES 3724

Answer to Can You Do It?

Proper meaning can be attached to the eccentric mathematician's statement only through the use of a system of numbers based on the figure five. For example, our present system of counting is the decimal system, based on the number ten. A figure such as 365 when properly analyzed really means:

$$3(10)^2+6(10)^1+5(10)^0$$

It will be noticed that the highest coefficient that each term can have is a nine. Thus, a number in the system based on ten is the summation of a series of numbers, each being a single digit times some power of ten.

A numbering system can be based on any figure whatever. There is at present a strong but numerically small faction of mathematicians who are advocating the adoption of the duodecimal system of counting, based on the number twelve. The particular problem given in this issue only makes sense when the number five is used as a base. No coefficients higher than four are then possible, and each coefficient signifies the repetition of some power of five. For instance, the figure 113 would mean:

$$1(5)^2+1(5)^1+3(5)^0$$

or 33 in the decimal system.

Multiplication and division become a little tricky, since many digits do not exist. Four times three would be twenty-two! Further, it must be remembered that something such as a tenth is not what it used to be, — as a look at the decimal point will prove — for a tenth in the quintinal system is a fifth in the decimal system.

Properly translated, the problem should read this way (in the decimal system):

"I could already read and write at the age of 5, so that I had little difficulty in entering the university at 16 years of age. I got my Ph.D. at 24, and one year later, as a man of 25, I married a beautiful young girl of 21, just out of college. The small difference in our ages made for common dreams and common interests. In four years we were a family of 5, father, mother, and children, which was just the right size, though we had a rather hard time financially. During the first year of our marriage I had only 100 dollars a month, and though this doubled eventually to 200 dollars, we were sorely pressed. I even had to give one-fifth of my salary to my mother, which left us with only 160 dollars a month till she died at the age of 75."

THIS IS M.I.T.
ELECTRICAL ENGINEERING

(*Continued from page 294*)

tecture; and the Nuclear Science and Engineering Laboratory in which a number of departments, including Electrical Engineering, have joint interest. Largest of the Electrical Engineering Laboratories are the Servomechanisms Laboratory, the Center of Analysis, the Laboratory for Insulation Research, tbe Laboratory for Instruments and Measurements and the Stroboscopic Photography Laboratory. Each of these research laboratories is functionally interdepartmental to a marked degree although administratively associated with the Electrical Engineering Department. For example, the Laboratory for Insulation Research involves equal work in the fields of physics, chemistry and electrical engineering.

All of these laboratories play a very important part in the Institute's educational program by giving both graduate students and staff active participation in new and stimulating investigations. Each of these labora-

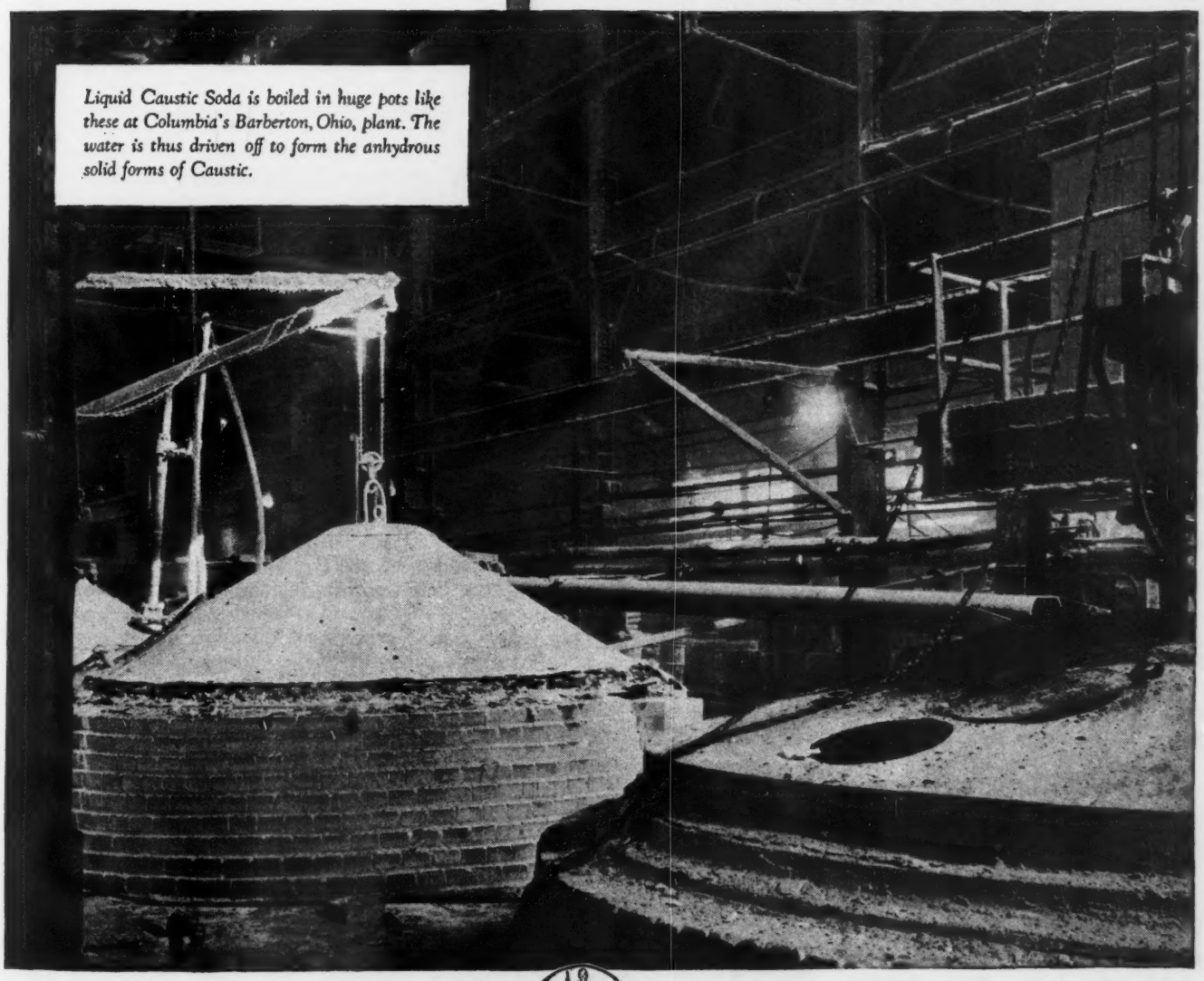
(*Continued on page 326*)

Columbia

supplies Industry with Essential Chemicals

- SODA ASH
- CAUSTIC SODA
- LIQUID CHLORINE
- CALCIUM CHLORIDE
- SODIUM BICARBONATE
- MODIFIED SODAS
- CAUSTIC ASH
- PHOSFLAKE (bottle washer)
- SODA BRIQUETTES (iron desulphurizer)
- CALCENE T (precipitated calcium carbonate)
- SILENE EF (hydrated calcium silicate)
- PITTCHLOR (calcium hypochlorite)

Many of the nation's basic industries—such as Chemicals, Glass, Paper, Soap and Textiles—are dependent upon alkalies and related chemicals for essential processes in their production. Columbia has served these needs since the beginning of the century.



Liquid Caustic Soda is boiled in huge pots like these at Columbia's Barberton, Ohio, plant. The water is thus driven off to form the anhydrous solid forms of Caustic.

COLUMBIA CHEMICALS

PITTSBURGH PLATE GLASS COMPANY • COLUMBIA CHEMICAL DIVISION

FIFTH AVENUE at BELLEFIELD • PITTSBURGH 13, PENNSYLVANIA

Chicago • Boston • St. Louis • Pittsburgh • New York • Cincinnati • Cleveland • Philadelphia • Minneapolis • Charlotte • San Francisco

ION EXCHANGE RESINS

(*Continued from page 316*)

additional pumping facilities are often unnecessary, since it is possible to obtain the necessary bed expansion at low backwash rates.

7. A non-siliceous composition. This precludes the possibility of an increase in the silica content of the treated water. As previously mentioned, some of the zeolites are attacked by waters with a high pH, with the resulting increase in silica content of the treated water, and the gradual disintegration of the exchanger itself.

8. Possibility of wide variation on the properties of the resins by varying the proportions and nature of the raw materials, thus making available specific resins for use under unusual application conditions.

The possible uses for ion exchange resins are as numerous as the resin types which are theoretically possible. Nearly every chemical industry is affected in some way by the ion exchange process, and many are possible only through the development of these materials. A forthcoming article will describe the many varied industrial applications, and indicate the methods by which the ion exchange process may be utilized.

THIS IS M.I.T.

ELECTRICAL ENGINEERING

(*Continued from page 324*)

tories has close contact with outside groups in government, in industry, and in other educational institutions. At the same time it has entire freedom to carry on those investigations deemed by M. I. T. to be most fundamental and most valuable in the Institute's primary function to train men.

The electrical-engineering field is currently enjoying extraordinary popularity. This is indeed fortunate for the large and varied industry that is clamoring for well-trained men. It is less fortunate for those fields that are equally needy of manpower but are less in the public eye. The important fact is that in all branches of science and engineering there is a very grave deficit of professionally trained men (as contrasted with technicians) in this country. This deficit at the professional level is all too evident in the electrical field. M. I. T. in general and the Electrical Engineering Department in particular are doing their utmost to make good this deficit which, however, is a task that will be ours for many years to come.

THE RESEARCH CENTER FOR GROUP DYNAMICS

(*Continued from page 291*)

tivity was about the same for democratic and autocratic clubs while laissez-faire clubs were much behind, but in the absence of the leader, autocratic clubs fell back to the level of laissez-faire clubs whereas democratic clubs maintained a fairly constant level. It also turned out that there were two types of reaction by the individual club members towards autocratic leadership, one of aggression, not against the leader but against each other, and one of apathy.

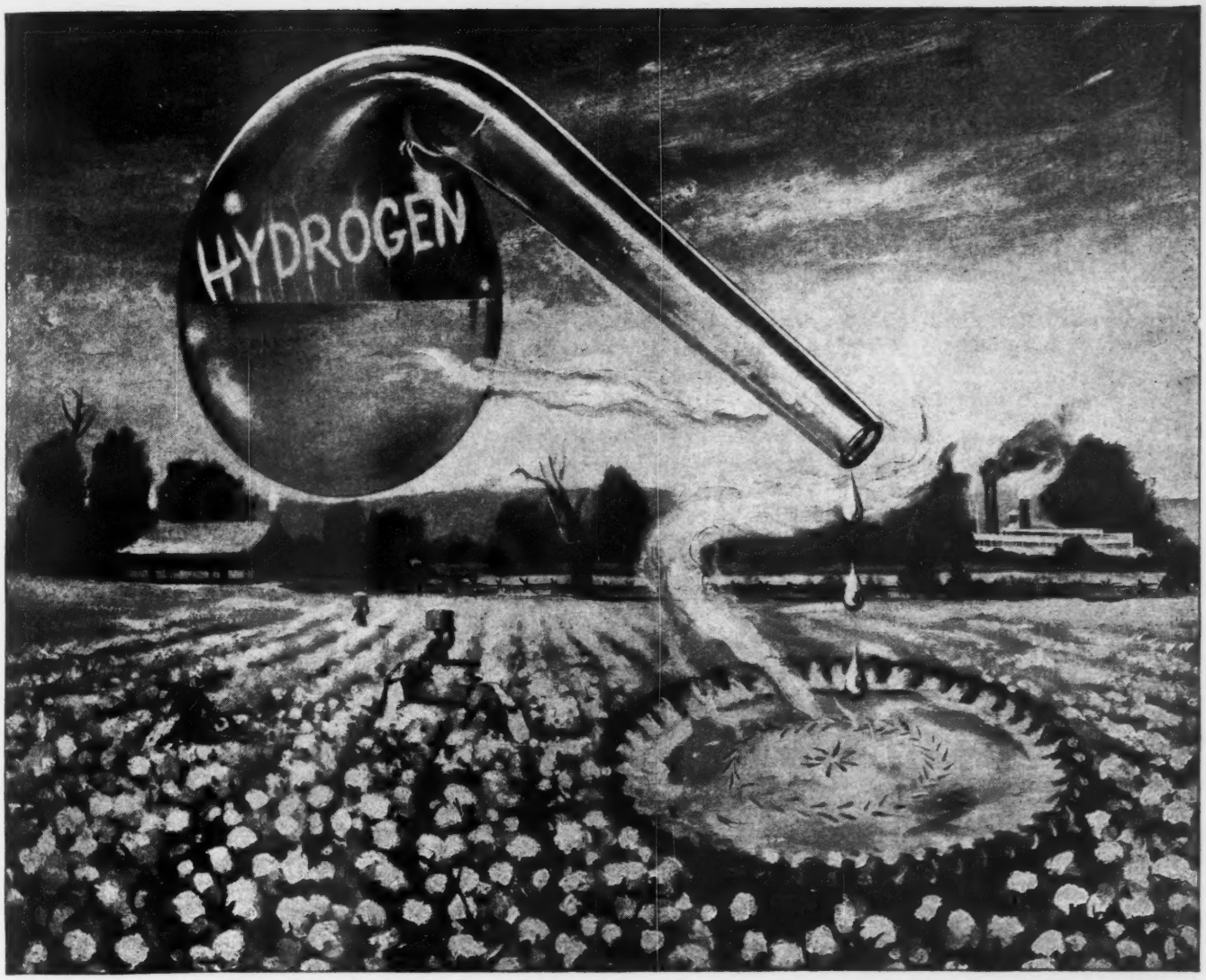
Other experiments carried out include investigating methods of leadership training, and the effects which lectures, individual instruction, requests, group discussion, and group decision have on subsequent group action. They form, however, just a point of departure for the Center and leave a vast amount of territory to be covered.

The practical applications of results obtained in such experiments can readily be realized when we consider, for example, how a factory manager has to take into account intricate interrelationships which are usually the work for experts in widely separated fields. It takes more than knowledge of production lines or accounting to run a business. An understanding of the cultural background of the workers and how they will react is also necessary.

The leaders of all forms of group life are increasingly becoming aware that, when derived from experimental fact, theories in the social sciences can be very practical. Laymen, also, are realizing that sound theory is a much better guide in dealing with other people than instinctive prejudice.

People have a justified dread of group manipulation, because it denies the fundamental dignity of man. It should be remembered, however, that everyone tries to influence the groups he belongs to, whether they be family, business, or social. Management in industry and all other fields is quite legitimate and necessary to the smooth functioning of society. Anything that will help management provide wise leadership by enabling it to sense more accurately the opinion of the group and by showing it how best to treat the group to accomplish whatever the purpose of the group may be, is valuable both to the group and the leader.

This picture shows one experimental arrangement used with children's clubs. The children wore cards which identified them to the observers sitting unnoticed behind the screen and taking stenographic and motion picture records of all that is said and done.



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Thanks to hydrogen gas and modern chemistry, American housewives now make pastry better and more economically than their grandmothers could. For hydrogen converts cottonseed oil and edible vegetable oils into popular-priced kitchen shortenings. It gives them body and stability so they stay fresh longer . . . do not quickly turn stale or rancid.

This process is one of innumerable operations that link Air Reduction to many basic activities of American life. Gases for welding and sign lighting . . . equipment for high altitude flying and underwater cutting . . . with these and many other related products, Air Reduction serves the progress of America.

The 56-page illustrated book "A Quarter Century of Progress" describes in detail the operations of Air Reduction and its subsidiaries. Write Dept. CP for your free copy.

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60 East 42nd Street. New York 17, N. Y.

Headache powder for industrialists

SEE this powder?

When formed under heat and pressure, it becomes *the hardest metal made by man,* CARBOLOY CEMENTED CARBIDE.

And Carboloy is doing more to help relieve production headaches in metal-working industries *than any other single factor in existence today.*

Consider these truths:

Carboloy tools and dies will cut, form or draw modern tough or abrasive alloys *with accuracy and at speeds never before thought possible.*

Today, more metal is being removed at higher speeds with cemented carbide than with any other material!

This amazing metal *commonly triples the output of both machines and men.*

Carboloy is considered by authorities to be *one of the ten most important industrial developments of the past decade.* For example, it is being used in ever-increasing amounts to wear-proof parts subject to extreme abrasion.

In most cases *it isn't necessary to get new machine tools* in order to secure immediate savings and faster production. You can put Carboloy Cemented Carbide to work for you today without a big investment—without any loss of time.

Throw this challenge back at us!

It's 10 to 1 our field engineers or research men can find ways for you to cut metal-working costs *and* increase the quality of your products with the use of Carboloy. Get in touch with us today.

Carboloy Company, Inc., Detroit 32, Mich.

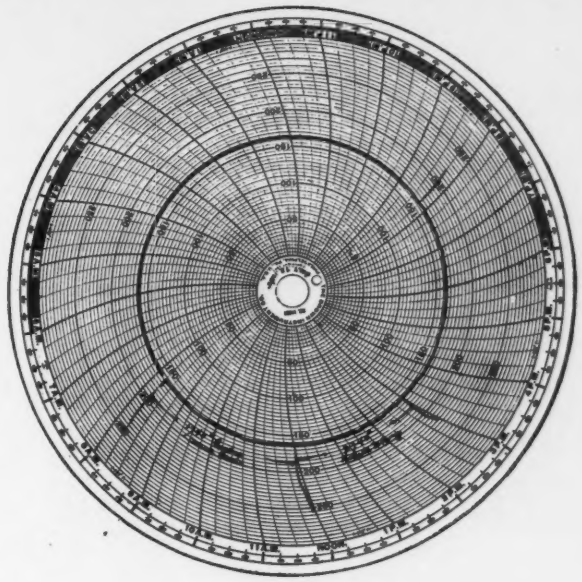
CARBOLOY

(TRADE MARK) • CEMENTED CARBIDE

The Hardest Metal Made by Man

One of the many advantages

of **GAS** and **MODERN GAS EQUIPMENT**



precise,

easy

and inexpensive

controllability

No other fuel for the industrial production line, where heat application in any form is required, lends itself so well to control of combustion and temperature as does Gas. The rate of flow, which determines heat input, may be varied over wide limits, at an infinite number of intermediate points.

Gas may be burned at the rate needed for the minute flame of a jeweler's torch. It may be fired at the tornadic intensity required in a furnace to heat treat steel billets 10 inches in diameter at 2250° F. In between and at even higher temperatures it is called upon to do scores of other jobs where temperature readings from control panels of Gas equipment show a fidelity to exactness that is unequalled in heat treating.

Gas controllability is, at the same time, very easy to obtain with equipment that is far less expensive to install and operate. This fuel knows no mere "on," "off" or "in-between" control, but, instead, close, accurate modulation to best serve industry. The local Gas Company's Industrial Engineer will, without obligation, advise how Gas and modern Gas equipment can bring their dual advantages to work for industry.

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FOR ALL
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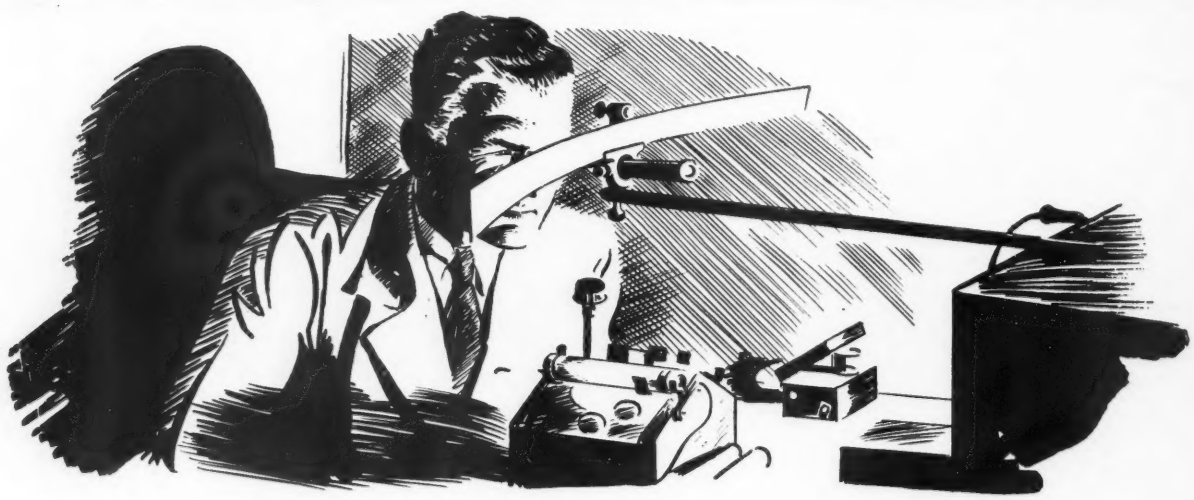
GE Campus News

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD



LIGHTING AT GENERAL ELECTRIC

The amount of knowledge accumulated in lamp making is enormous. Some of this knowledge is committed to paper, but some of it is only to be found in the heads of technical and production men in the laboratories and in the factories. Among these men are scores who, on leaving their technical colleges, have since directed their special training to developing better lamps for less money.

The manufacturing operations of G.E.'s Lamp Department are far-flung, its 36 plants being scattered about the country in 17 cities. Of these, one plant makes machines and other special equipment for making lamps; ten plants are glass works; eight make parts, tungsten wire, gases, chemical products, bases); and 17 are lamp factories. Altogether they add up to 94 acres of floor space roughly equivalent to an eight-story, mile-long factory a hundred feet wide.

The huge workshop of the Cleveland Equipment Works of General Electric's Lamp Department, for example, employs men with a great variety of skills, among them design and mechanical engineers—and they devote all their time and energy to creating, simplifying, and perfecting machines for lamp making which are truly marvels of ingenuity.

IMPROVING THE PRODUCT

The goal of G-E Lamp Research has always been to produce the best possible lamps for every lighting service—at the lowest cost.

Over the years, lamp prices have been repeatedly reduced while lamp efficiency has steadily improved. For example, the present 60-watt lamp bulb is 56 per cent brighter than its ancestor of 1923; yet it costs only one-quarter as much.

G-E Fluorescent lamps, first introduced only eight years ago, have followed the same pattern. Today they cost only about 40 per cent as much as in 1938. They last longer and are far brighter. In fact today they are eight times better value for the user than originally.

Seat of Learning

Years ago someone coined the phrase, "University of Light" as applying to Nela Park, Cleveland headquarters of the Lamp Department of General Electric. The men who work there have taken the lead in developing the art and science of better lighting, as well as new and better lamps.

This advertisement is one of a series discussing opportunities for young men in fields in which General Electric has made important contributions. General Electric Company, Schenectady, N. Y.

963-112C-211

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